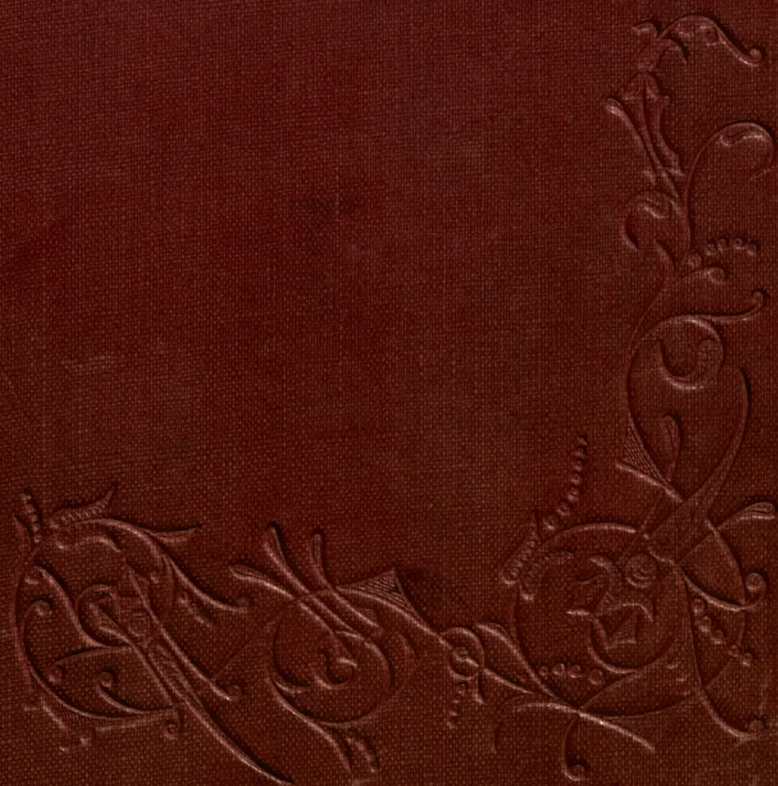


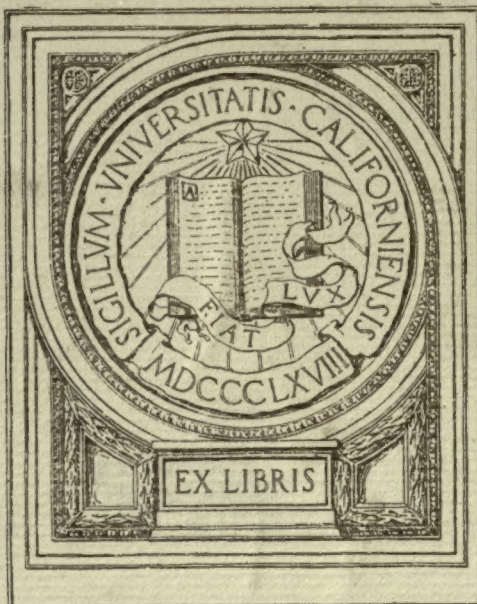
A RESEARCH  
ON  
THE EUCALYPTS  
AND THEIR  
ESSENTIAL OILS

BY  
RICHARD T. BAKER  
AND  
HENRY G. SMITH.





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# A RESEARCH ON THE EUCALYPTS

ESPECIALLY IN REGARD TO

THEIR ESSENTIAL OILS.







DEPARTMENT OF EDUCATION.  
NEW SOUTH WALES.

---

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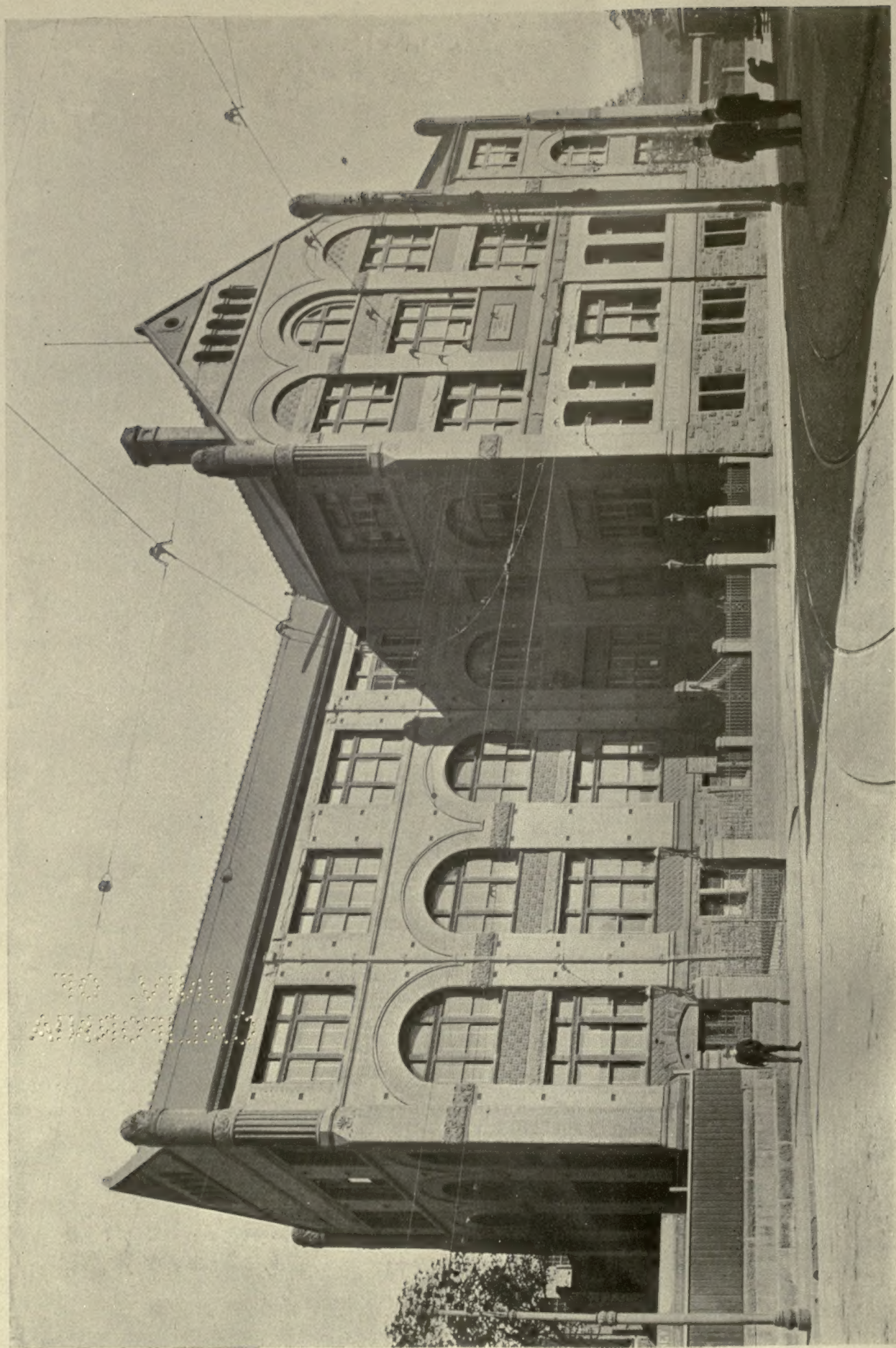












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Technological Museum, New South Wales.

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A RESEARCH ON  
THE EUCALYPTS  
ESPECIALLY IN REGARD TO  
THEIR ESSENTIAL OILS.

**[2nd Edition.]**

BY

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## PREFACE.

---

THE continual applications received by us, during the last few years, for further data concerning the physical and chemical properties and commercial possibilities of the oil products of the Eucalypts—than those given in the first edition, which has now been out of print for some time—were the chief incentives which moved us to place our latest researches on these wonderful trees into the present book form.

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 species found in all the

### ERRATA.

- ge XV. CV. should read CX.  
 ge XV. CVIII. (first one) should read CVII.  
 ge 16. Third line from bottom, Plates I., II., III. should read III., V., VI.  
 ge 17. Line 30 from top, Plate III. should read VI.  
 ge 18. Third line from bottom, Plates VI., VII., VIII. should read IX., X., XI.  
 ge 19. Line 27 from top, Plates I. to VIII. should read III to XI.  
 ge 357. The word Deposit at end of list should be same type as Paraffin, from  
 which it is a distinct substance.  
 ge 425. The sign missing in the centre of table before  $12^{\circ}$  is - (minus).

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growing in localities difficult of access and far from rail and road communication, and although expert collectors were employed for this work, yet the difficulties of location were none the less in evidence.

As illustrating this difficulty of collection in such sparsely settled countries as Australia and Tasmania, Plate cxx is given.

In the main the scheme of the original edition is again followed, although, of course, much amplified in various directions, in agreement with the many new discoveries and fresh facts brought to light during the last twenty years.

Where possible the data given in the first edition have been verified and extended by further researches on new and larger quantities of material of the same species, growing under varying climatic and geological conditions. With one or two minor exceptions the chemical and botanical information as previously recorded still stands, and is supported by these more extended investigations.

To every section has been added the accumulated results of our labours in this direction, during past years, in the research laboratories of this Institution.

These results clearly show that in the Genus Eucalyptus, Australia has a commercial Forest asset of so diversified and valuable a nature that it has no compeer in any other genus in the whole botanical world.



TO: MR. J.  
FROM: MR. J.

100





## PREFACE.

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In the previous edition the species more particularly investigated were those restricted to the South Eastern area of the Continent, but since that publication was issued the research has extended to species found in all the States of the mainland, as well as those of Tasmania.

No pains have been spared in the endeavour to insure that the material worked upon was true to name—botanically correct; and in order to determine the constancy of the product from individual species, material has been collected from widely separated localities, so that commercial requirements for uniformity might be satisfied.

The collection of such a mass of material for investigation was no small task, the genus being distributed over an area of about 1,000,000 square miles of territory, more particularly when it is understood that, with two or three exceptions, all the distillations were carried out in Sydney under our own supervision, the necessary botanical control being, in this way, well assured.

Eucalyptus species are often very local in their distribution, frequently growing in localities difficult of access and far from rail and road communication, and although expert collectors were employed for this work, yet the difficulties of location were none the less in evidence.

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These results clearly show that in the Genus *Eucalyptus*, Australia has a commercial Forest asset of so diversified and valuable a nature that it has no compeer in any other genus in the whole botanical world.



Especially is this noticeable in the great variety of timbers and oils, the latter of which is specially treated in this work, the former being monographed in a separate publication by one of us, and issued from this Museum:—No. 23 of the Technical Education Series.

Since the publication of the 1st edition, the Eucalyptus oil industry has expanded considerably its scope of usefulness in the industrial world, as for instance the utilisation of certain oils in the mineral flotation process for the extraction of metallic sulphides, for perfumery purposes, for solvents, and the preparation of proprietary articles.

Besides the amplification of the letterpress and subject matter in the first edition, many new features will be noticed, as, for instance, the sections of leaves in colour photography, magnified by various diameters, which will give some idea of the position of the oil in the leaf. Chromatic photography was employed in this way in order to show more clearly the differentiation of the anatomical structure of the leaf. The bark illustrations also give some idea of the natural groups into which the trees are divided on a cortical system.

A series of plates is added, showing the various systems or methods of extracting the oil from the leaf in Australia.

As we have now reached the age limit for retirement as laid down by the Government Service Regulations, and so will shortly leave this field of our scientific activities in which we have laboured so long, and, we hope, with some small measure of success, this will be the last joint monograph by us. We therefore take this opportunity of placing on record our appreciation of the far-sighted policy of our Department of Education (of which this Museum is an integral part)—a policy that has encouraged and enabled us in our research work, to endeavour to bring to light for the benefit of pure and applied science some of the hidden mysteries of Australia's unique and wonderful Flora.

November, 1920.

R.T.B.

H.G.S.





## ACKNOWLEDGMENTS.

---

A WORK of this character, the preparation of which has now extended over many years, and covers such a wide range, has necessarily caused us to solicit the help of others residing in the various Australian States, and in every instance this assistance has been readily and generously given. Due acknowledgment was made in the first edition, whilst in this, the second edition, we gratefully recognise the help received in various ways from the following:—

To the members of the Scientific Staff:—Mr. M. B. Welch, B.Sc. (Sydney), Economic Botanist, for valuable help by assisting in the reading of proofs, and in other ways, but more particularly do we wish to acknowledge the sectioning of the leaves for their chromatic illustrations, reproduced in this work. Mr. A. R. Penfold, F.C.S., Economic Chemist, for chemical assistance in the later part of these investigations, particularly in connection with piperitol, terpineol, the aromatic aldehydes and cineol estimation. Mr. T. C. Roughley, Economic Zoologist, for the Eudesmol and Australol photographs, and Mr. C. F. Laseron, for collecting the material.

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FRONTISPIECE. Technological Museum, Sydney.

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PART I.

---

INTRODUCTORY.







# THE GENUS EUCALYPTUS.

NATURAL ORDER

## Myrtaceæ.

THIS Genus was first named *Aromadendron* by Dr. William Anderson, the surgeon of Captain Cook's second and third expeditions, when collecting with Captain Furneaux in Tasmania, where Hobart now stands. According to Mueller, the first species named was a "Stringybark," now known as *E. obliqua*.

The name *Eucalyptus* was bestowed by L'Heritier in 1788 (Sert. Angl., 18, t. 20), the word being derived from the Greek εὖ "well," and καλύπτω "I cover," in allusion to the operculum or lid which covers the calyx until the stamens are fully developed.

Robert Brown gave the not inappropriate appellation of *Eudesmia* to the genus in 1814; but, of course, this name is synonymised by the rule of priority.

Still later another name was proposed, *i.e.*, that of *Symphyomyrtus*, by Schauer, in 1844.

The trees are evergreen, either tall and of enormous height, or dwarfed shrubs, when they are known as "Mallees."

The bark is variable in its nature and texture, being either rough, furrowed, or smooth, features which are more fully described under each bark illustration.

The leaves, as a general rule, are larger on young trees, or adventitious shoots, than on mature trees, whilst in some species they are first opposite and sessile, and then alternate and petiolate. The usual shape is lanceolate, falcate, and, being fixed vertically instead of horizontally, give less shade from the sun's rays than most trees. They also possess the power of twisting on the petiole, probably for the purpose of exposing the thicker cuticle of the leaf to the sun, and thus minimising the volatilisation of oil.

Oil glands are present in the leaves of almost every species, being very pronounced in those of some groups.

The inflorescence is either axillary or terminal,



The flowers have no petals, and the stamens, which with one or two exceptions, are white, inflexed in the bud, and expand when nature removes the operculum.

The fruit consists of a variously enlarged, indurated, truncated calyx tube or capsule, three- to six-celled.

The seeds are small and very numerous, the sterile ones predominating.

The Genus *Eucalyptus* is of immense importance, whether considered in reference to the timber, essential oils, dyes, perfumes, or kinos. Its trees probably form three-quarters of the whole vegetation of this continent, but the number of species, about 300 odd, can hardly be considered large with such a wide geographical range, the area of Australia being over 3,000,000 square miles.

## Systematic Classification here adopted.

WHEN this research was first commenced it was intended to follow the usual morphological systematic classification of previous botanists; but, as the work progressed, it was found that nothing definite could be arrived at if such a course were followed.

By working on morphological grounds alone, it was found that many of the so-called individual species possessed different barks, timbers, oils, dyes, &c.—a state of things which quite differed from our definition of a species. Such an artificial system (as this research appeared to prove it) had to be discarded, and what is, apparently, a more real or natural system of classification had to be adopted, viz., founding a species, not on morphological characters of dried material alone, but on—

1. A field knowledge of the trees;
2. The nature and character of their barks;
3. The nature and character of their timbers;
4. Morphology of their fruits, leaves, buds, &c.;
5. Chemical properties and physical characters of the oils, dyes, kinos, &c., and the utilisation of any other evidence, such as histology, physiology, &c., that might assist in establishing differences or affinities of species.

Our experience, extending now over a period of thirty years, shows that a species founded on the above system as laid down in our first edition is found after these years, to be practically constant in specific characters, however great the range of distribution may be, and many evidences of this fact will be noticed throughout the work. In the very few exceptions to this rule, reasons for the divergence seem to be clear.

Necessarily a classification of species on such a broad basis has not always led us to coincide with the opinions and decisions of previous, as well as contemporaneous, botanical workers on the genus. Our experience verifies the remarks of the late Dr. Woolls, who states:—

“Many of the trees which differ very widely in the texture of their bark and the specific gravity of their wood, and to all intents and purposes are perfectly distinct from each other, yet agree very nearly with ordinary characters by which species are regulated, so that a written description, especially from dried specimens, may be applied to half-a-dozen different kinds of “Gum.” Indeed, this has frequently been the case, and even amongst men of scientific attainments, as might be easily shown by referring to the various works which have been written on the subject.” (*Flora of Aust.*, p. 213.)

By the method of classification here advocated and adopted, no such confusion of trees is possible.

This research does not in the least favour the uniting of species, and several of those that have been synonymised in the past are here restored to their original specific rank. It was found that the old morphological classification was untenable in particular cases, so also was it recognised that descriptions and original material of some species were made to include, under the one name, trees which were evidently distinct from each other, and these are separated in this work; for instance, under *E. Stuartiana*, were included in descriptions and



original herbarium material of Mueller, the "Victorian Apple," the "But But" of Gippsland, and the "Apple" of New South Wales. These two latter represent the same species, possess distinctive characters from the former, and have been given the name of *E. Bridgesiana*.

On the same grounds, from *E. polyanthemos*, Sch., have been separated *E. Fletcheri*, R.T.B., *E. ovalifolia*, R.T.B., and *E. Dawsoni*, R.T.B., which are all good and distinct species, based on a natural classification. Several similar cases may also be noted in this work.

We have placed little value upon supposed varieties of Eucalypts morphologically determined, because at the best they can only be varieties of varieties, and are thus likely to cause confusion. After all, the difference between a variety and a species is only one of degree, and much must be left to one's judgment as to how far the division or subdivision is advisable.

Whatever differences of opinion may be held in regard to the nomenclature of the species as we now submit them, there can be no doubt as to the particular trees from which the material has been obtained for the research, and this, of course, will be found of the greatest importance both scientifically and economically.

It is evident that the main object of naming the species is for the purpose of recognition, and any simplification in this direction should certainly be considered advantageous.

As the result of this research it can now be stated what are the special yields of oil and their chemical compositions, and because of the practical constancy of constituents in the oils obtained from identical species, it is also now known what the prospective value of such an oil may be, and it can also be stated with some certainty what is its comparative value.

The uniformity of results and the regularity of specific characters has enabled some order to be evolved, which is altogether most satisfactory.

This investigation embraces nearly the whole of the known species in New South Wales, Victoria, Tasmania, and South Australia; a few from Queensland, and about a dozen from Western Australia. It will thus be seen that the oils of most of those species peculiar to the north and north-western portion of the continent yet remain to be determined.

The botanical systematic portion of this work, the figures and other data illustrating the species, are given because of the importance to be attached to the combined botanical and chemical results, thus leading to a more accurate foundation or scientific basis, upon which to establish this important essential oil industry.

The investigation of vegetable products on more than the botanical side is becoming characteristic now of workers in many parts of the world, and we think, that future work on the economics of the Australian flora, should be also conducted by the united efforts of botanist, chemist, physicist, and other workers in cognate sciences, for thus only can be attained a complete knowledge of any plant and its products. One sees the same line of action being pursued to-day in other fields of natural science, for instance the co-ordination of physics and chemistry, with the result that physical chemistry has ultimately emerged as a definite branch of natural knowledge, and similar instances will readily occur to the reader.

Botanical material of all the species from which oil has been extracted is preserved for future reference, should any doubt arise as to the specific origin of any of the essential oils.

## Comparative Constancy of Specific Characters of Eucalyptus Species.

THE reputed or supposed great variation of individual *Eucalyptus* species has arisen probably by the attempts of botanists to found species on *morphological characters alone*; and Bentham, when working on this system, experienced great difficulty in finding any constant feature upon which even to establish groups, and had to discard such differences as opposite or alternate leaves, comparative length of the operculum, length of calyx tube, &c. He finally selected the shape of the anthers as a means of classification, but even this has since been found to be defective and is open to objections. Bentham evidently felt that even this was not such a natural classification as he would wish, because in his remarks, (*B. Fl.*, iii, p. 186), he expresses a hope that a "truly natural arrangement may be founded on a knowledge of the 'Gum' trees in a living state, upon the proposed cortical or on any other system which experience may suggest." However, we are quite in accord with him when he states, concerning his classification, that "the groups pass very gradually into each other through intermediate forms," and our results confirm this gradation of groups; but it is the individual species that shows a comparative constancy of specific characters throughout its known geographical distribution. Not only is this the case with the botanical characters, but also in their chemical constituents, a conclusion fully confirmed by the mass of evidence we are now able to submit in connection with the species here enumerated, and as the result of a research extending over a period of thirty years.

The most serious objections to Bentham's antheral system are:—

1. That of placing in the same group, and in juxtaposition, species which to those familiar with the trees in the field, are perfectly distinct from each other; and
2. That of separating under various sections trees which by bark, wood, habit, general characters, chemical properties of their oils, kinos, dyes, &c., ought to stand near to each other.

For instance, in the former case, with the smooth-barked "Mountain Gum" (*E. goniocalyx*), the "Bundy Box" (*E. elæophora*), was confounded or associated. The "Apple" of Victoria, with its red timber and stringy bark, was placed with the "Apple" or "Woollybutt" of New South Wales (*E. Bridgesiana*), a tree with a pale-coloured timber, and a "Box" bark; numerous other examples could also be given, and similar associations will no doubt occur to any student of the Eucalypts.

The second case could be illustrated by the "Ironbark" trees, which might be grouped together, but yet stand apart; whilst with them were included the "Scribbly Gum" (*E. hæmastoma*), "Tallow-wood" (*E. microcorys*), and others—trees which have quite distinctive characters and should be separated.

Probably it has been the effort to utilise this and similar systems that has led to the acceptance of the idea of great variability of Eucalyptus species, but from the results of this extensive study we consider that only in exceptional cases do such nuances exist, even under a natural classification.



Dr. Woolls (*Fl. Aust.*, p. 217) states, under his article on the Eucalypts:—  
 “Whatever merit there may be in an artificial system by which museum plants can be named, . . . I do not think that such an arrangement will ever meet with much favour with those who are studying the living plants.”

By adhering closely to the system which we advanced in the first edition of this research, and have followed since the publication of that work eighteen years ago, it is found that the species show, comparatively, not much variation; in fact, possess such a constancy of specific characters, that is surprising in the light of previous published literature on the Eucalypts.

Statements that a species in one locality has a smooth bark, and in another locality has a “Stringybark,” and sometimes an “Ironbark,” are not verified by our work. For instance, it was at one time recorded that the “Scribbly Gum” (*E. hæmastoma*, Sm.) was occasionally found as a “Stringybark.” Investigation proved that no such variation existed, and that the tree with a “Stringybark” is quite distinct from the smooth-bark,—“Gum” (*E. hæmastoma*, Sm.), and has a good geographical range and a constancy of specific characters distinct from *E. hæmastoma*, and so it has been separated and botanically named *E. Wilkinsoniana*; it is commonly known as “Small-leaved Stringybark.” The red rim of the fruits appears to be the main connecting character of these species, and this feature has little discriminative value.

The reputed variability of the species of the genus might possibly have arisen, because—

1. Original descriptions were so brief, and material too indefinite, as to be practically useless. Dr. Woolls was of this opinion, for he states: “When I find writers of some eminence referring very different trees to the same species, I cannot but see the inadequacy of the descriptions hitherto relied on.” All such doubtful descriptions have been ignored in this work, as there appears to be no finality in trying to match material to such vague diagnoses and fragmentary specimens.
2. Too much reliance was placed on herbarium specimens. Botanical systematic work can generally be carried out on dried material in most instances, but in the case of the Eucalypts it is not the only evidence needed, as some of the essential natural characters are not represented in such material.
3. Common names are used too indiscriminately. In almost every work on the Eucalypts, one finds a number of common names appended to the botanical one. In the light of our present knowledge most of these common names can be shown to refer to distinct species. In this work the common names have been subordinated to the botanical, being considered of secondary importance.
4. Sufficient attention has probably not been given to field botany in the determination of many Eucalyptus species. Dr. Woolls may be again quoted in that he states: “Trees placed by botanists under one specific name would never be so considered if studied in nature, for there the specific differences are so marked that no one would ever think the trees were one and the same species.” Our researches confirm this statement; and numerous instances of this fact might be given here.

The comparative constancy of specific characters, morphological and chemical, such as the constituents of the oils, dyes, tars, &c., amongst the Eucalypts is perhaps only what one might expect to find, when it is assumed that this continent is one of, if not, the oldest on this planet, having evidently remained stationary during certain subsidences and upheavals of other parts of the earth, and so preserved the fauna and flora of past geological times.

During the extensive period thus represented, the species have materially differentiated from the parent stock, and have so well established their individuality that the evidences here published show but a few species undergoing varietal evolution at the present time. That there are variations cannot be denied, but they are comparatively few when the extensive range of the genus is considered. With the exception of about half a dozen, all the Eucalypts enumerated in this work will be found to possess comparatively constant characters throughout their geographical distribution. On the whole, therefore, we think the Eucalypts may be regarded as fairly invariable. It must, of course, be admitted that herbarium material of Eucalyptus species can be so arranged as to show perfect gradations; but then all other physical characters are ignored.

Further, it is found that the constituents occurring in the oils of all those species about which there is no difference of opinion are always in agreement, and only differ in amount within the limits experienced with the oils of all the species at varying times of the year; it may also be that this rule applies to all those species about which little has been previously known. Several instances of this constancy of constituents will be found under the respective species in this work.

The late Baron von Mueller, who had a most extensive knowledge of the Eucalypts of Australia, recognised the assistance that might be rendered to the botanist in the discrimination of the different species by the chemical investigation of their several products. The following reference is from his "Eucalyptographia," Decade III, article *Eucalyptus piperita*, published in 1879: "*E. obliqua* is distinguished from *E. piperita* by . . . and perhaps by anatomic, histologic, and chemical peculiarities of the bark and wood, which characteristics remain yet more comprehensively to be studied."

Since the time the above was written much has been done in determining the chemical characteristics of many of the species, and the results are of so satisfactory a nature in this connection, that it must be apparent that no investigation of the Eucalypts over any one portion of the continent can be considered complete or conclusive, without it embraces also the chemical investigation of their several products, and other physical characters. This is well illustrated by the several species that have previously been classified under the name of *E. amygdalina*.

In a paper by Dr. Gladstone on Essential Oils (*Journ. Chem. Soc.*, 1864, p. 3), the oil of *Eucalyptus amygdalina* is stated to have a specific gravity of 0.8812 at 15.5° C., a rotation for a column having a length of 10 inches, of —136°, or corrected for optical rotation  $\alpha_D$  —53.54°, and refractive index for  $D=1.4788$ . From what is shown in this work under *E. phellandra*, there seems little doubt but that this particular sample of oil was obtained from *E. dives*. If these figures are compared with those for this species distilled recently, it will be seen how closely they agree, so that the constancy of the products obtainable from this species of Eucalyptus is thus indicated.

The specific rotations given by Mr. W. Percy Wilkinson (*Proc. Roy. Soc.*, Victoria, Vol. VI, p. 197), for various samples of supposed *E. amygdalina* oils, varying from —88.9° to —16.3°, show, when compared with our results, that these samples of oil had been obtained from more than one species. The specific gravities given in the paper also suggest the same conclusion. This grouping of the species on a morphological basis illustrates the difficulties under which Mr. Wilkinson laboured in his commendable attempt at that time to extend our knowledge of Eucalyptus oils.



The differences in results recorded for the oil of *E. amygdalina* in various works on "Essential Oils" can be accounted for in the same way, and this is probably so in all cases where the oil of *E. amygdalina* is recorded as showing great variability.

It only requires to be mentioned that the constituents of the oil of *E. globulus* are practically constant from whatever locality the material is obtained, and the sample of oil from this species that we distilled from material collected at Jenolan, New South Wales, differed in no respect from the product of trees growing in Tasmania, or in Victoria. M. Voiry, in his paper, *Compt. Rendus*, 1888, p. 1419, also expresses this constancy in the following paragraph:—" Cette propriété est commune à tous les échantillons d'essence d'*Eucalyptus globulus* de différentes provenances que j'ai pu examiner . . . . "

Messrs. Faulding & Co., of Adelaide, in 1901, kindly supplied us with the crude oil of *E. cneorifolia*. The oil of this species is usually lævo-rotatory, the lævo-rotation being caused by the aldehyde aromadendral; and not by phellandrene, as that terpene does not occur in this oil. The oil had a rotation in a 100-mm. tube, for the crude oil, of  $-5.4^{\circ}$ ; that of the rectified oil being  $-3.0^{\circ}$ ; the specific gravity of the crude oil was 0.9287 at  $15^{\circ}$  C. An analysis made in 1891 by Mr. Robert H. Davies, of Apothecaries Hall, London, of the oil of *E. cneorifolia* for Messrs. W. Cumming & Co., Adelaide, showed the sample to have a rotation in a 100-mm. tube of  $-3.53^{\circ}$ , and a specific gravity at  $60^{\circ}$  F. of 0.923.

A recent analysis of the oil of this species published in this work, also shows concordant results, so that with this species there is a remarkable agreement also, particularly as this is one of the heavy *Eucalyptus* oils.

The oil of *E. hemiphloia*, in the work on "Volatile Oils," by Gildemeister and Hoffmann, published by Messrs. Schimmel & Co., is stated to contain cineol and a large amount of cuminic aldehyde (now shown to be lævo-rotatory aromadendral). Our results showed cineol to be present in good quantity, and aromadendral also. It was from the oil of *E. hemiphloia* that the aromadendral was prepared for the purpose of research. *E. hemiphloia* is a well-defined species, and but little error should arise in its determination, consequently results agree.

In this connection it might be well to refer to *E. hæmastoma*. This species was named by Dr. Smith, in 1797, from trees growing at Sydney, in which neighbourhood it still occurs, so that there is little doubt as to the particular tree referred to by him. But there is one species (now *E. Wilkinsoniana*, R.T.B.), which was for a long time thought to be a "Stringybark" form of *E. hæmastoma*. If someone had investigated the oil stated to have been distilled from this species and supplied under the name *E. hæmastoma*, different results would certainly have been obtained, the oil of *E. Wilkinsoniana* consisting very largely of lævo-pinene.

The "Red-flowering Ironbark" (*Eucalyptus sideroxylon*) is a species which extends over a large area of country, so that it was possible to obtain material from localities very widely separated. Throughout this area the morphological characters of the species are practically constant, and the nature of the bark and timber shows no variation in general characters—a remark which is also applicable to the other species enumerated in this work. Leaves were received from Liverpool, near Sydney, in December, 1900; from Condobolin in March, 1901; and from Narrabri in July, 1901. These localities are about 350 miles apart, and if connected would form almost an equilateral triangle. The crude oils were in all three cases practically identical, only differing in the amounts of constituents, as might be expected from trees belonging to identical species,

whether growing only a few feet from each other or miles apart. The results here recorded are a good illustration of the constancy of chemical constituents in oils of the same species.

| Locality and Date. |     |     | Yield<br>per cent. | Specific<br>gravity<br>at 15° C.<br>Crude oil. | Optical<br>rotation<br>$\alpha_D$<br>Crude oil. | Cineol, determined by<br>the phosphoric acid<br>method (O.M.).<br>Crude oil. |
|--------------------|-----|-----|--------------------|------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------|
| Liverpool, 1900... | ... | ... | 0.743              | 0.9227                                         | + 1.90°                                         | 60 per cent.                                                                 |
| Condobolin, 1901   | ... | ... | 0.503              | 0.9189                                         | + 3.19°                                         | 57 per cent.                                                                 |
| Narrabri, 1901     | ... | ... | 0.487              | 0.9201                                         | + 1.39°                                         | 58 per cent.                                                                 |

The low ester value, the absence of an excessive amount of volatile aldehydes, together with the large amount of cineol, are characteristic of the oil of this species. Perhaps *E. obliqua* is even a better illustration of this chemical agreement as can be seen under that species.

Many other instances might be mentioned in which this constancy of chemical constituents is demonstrated, not only from our own results, but also in connection with those obtained by previous observers, although unfortunately, precise data in this connection are often wanting; but those mentioned above are sufficient to show that, when no error has been made in the botanical diagnosis, and no mixing of the leaves has taken place, the chemical results will be unmistakable also.

If it is possible to show that this is so, then the corollary must be that the same species of *Eucalyptus* will give practically the same oil, and consequently the commercial aspect of the question is placed upon a sure foundation; not only from the commercial side of the question is this important, but this constancy of constituents must be taken into consideration in the diagnosis of doubtful species. Supposed allied forms that do not individually show chemical constituents in close agreement cannot consequently be the same species.

As an instance of how this confusing of species has appealed to other workers on *Eucalyptus* oils, the remarks of Gildemeister and Hoffmann, in the work above quoted, may be mentioned. Two oils supposed to be from *E. dealbata*, were under review, and they say, "that it is impossible for it" (the second sample) "to have come from the same plant" (as the first sample).

We have received much help towards settling doubtful botanical points since the discovery of this constancy in chemical constituents was made, the results assisting much towards demonstrating differences between the several species, which, otherwise, could not have been decided so satisfactorily. When these differences have been detected, further research has shown well-marked morphological characters to be also present—in fact, so distinct that the species cannot again be confounded with others; or, in other words, we have learned its history and found its place in nature. The exceptions to this are very rare.

As a further evidence of the comparative constancy of *Eucalyptus* species, one need only look to their introduction into other countries, where they retain all their physical characters and morphology, as obtains in their native habitat.



The theory has often been advanced that the chemical constituents of the same species vary in different localities, but this idea is not verified by our experiences as regards the Eucalypts, as they do not show those differences in chemical constituents that might perhaps be expected from differences of soils or localities. The reverse may possibly be accounted for by the natural selective, ecological peculiarities shown in many instances by the species themselves, as it is remarkable how a certain species will flourish on a particular geological formation and become singular to like formations, while at the same time objecting to those entirely different. However that may be, those influences do not appear to act detrimentally, or to interfere in any way with the practical constancy of results.

## Hybridisation.

THIS very fascinating question has occupied the attention of modern botanists to some extent, and we also have given some thought to the subject, but so far without any measure of success. On seriously following up the identity of supposed *Eucalyptus* hybrids, in several cases, the contention that these were the offspring of certain indicated parents, has been found to be without solid support.

Natural hybridisation in the *Eucalypts*, perhaps, appeals to one as a feasible explanation for the establishment of certain species which show affinities on both sides. The organs of reproduction in *Eucalyptus*, however, are protected by an operculum, and in many cases pollen grains are found adhering to the stigma before the operculum falls off, so that it may be just as readily supposed that the cap in the bud stage is a protection against hybridisation.

Baron von Mueller at one time did not regard hybridisation as impossible, but thought that all ordinary chances are against it, for he states : " Hybridisation does not seem to explain the origin of these aberrant forms in a genus, where cross-fertilisation is guarded by a calycine lid." (*Eucalyptographia*, 8th Dec., under *E. cordata*.)

It may be now shown that most of these supposed aberrant forms are really distinct species, and in our opinion cross-fertilisation in the *Eucalypts* under natural conditions is quite exceptional, especially when we know that numerous species are growing intermixed, often flowering at the same time, and so under supposed favourable conditions for hybridisation, yet preserving throughout extensive areas their specific characters with remarkable constancy.

We were very much impressed with this aspect of the question on the completion of our work on the *Eucalypts* of Tasmania, and it was striking to find such a large percentage of the species (quite half) of those now growing in Tasmania, which are identical, both botanically and chemically, with the same *Eucalypts* growing on the mainland of Australia. It is thus evident that these species were well established in both Australia and Tasmania before the latter was separated from the continent, and that in both localities they have gone on reproducing their offspring in absolute constancy ever since. It is thought that it was not earlier than tertiary times when Bass Strait was formed, and although this period is perhaps not far back geologically, yet, considered botanically, it must have been a very long time ago ; but, through all this period of time only a very few species of *Eucalypts* have become endemic in Tasmania. It may be mentioned that since our work on the Tasmanian *Eucalypts* was completed, *E. acervula*, which was considered as endemic in Tasmania, has also been found growing in South Australia ; and possibly when the *Eucalypts* on the Australian Alps shall be more completely studied, other Tasmanian species will be found to exist on the mainland also. How very different this condition of affairs must have been if hybridisation were a common occurrence with the *Eucalypts*. It is thus evident that very definite knowledge is needed before one can accept the statement that such and such a *Eucalyptus* tree is a hybrid under natural conditions.

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## Nomenclature.

WHEN the first edition of this work was published in 1902 it was decided to subordinate the vernacular names to the scientific, as it was found that no uniformity of results were obtainable if the vernacular names were relied upon to any extent for systematic and industrial purposes.

In a work with a commercial setting such as this, the idea was no doubt somewhat revolutionary at that time, but after some years' experience we are quite satisfied with the result of that action, in so far as it concerns the Eucalyptus oil industry, and we trust that the method will be more extensively adopted with the Eucalypts in other directions, especially the timber trades.

The number of distinct species of Eucalypts is so large that sufficient common names could only with difficulty be invented in order that each species may have a distinctive appellation, and consequently we often see a conglomeration of species with different economics under the one common name. There are, for instance, several species known as "Blue Gums," many others as "Red Gums," "White Gums," "Boxes," "Peppermints," "Mallees," "Iron-barks," or "Bloodwoods," so that in this direction identification with any degree of success for accurate economic purposes becomes quite hopeless. Some attempt has been made to overcome the difficulty by employing an adjective, so that we have "White Box," "Murray Red Gum," "Broad-leaved Peppermint," and so on. It is just as easy, however, to say *Eucalyptus rostrata* as "Murray Red Gum," or *Eucalyptus dives* instead of "Broad-leaved Peppermint" or *Eucalyptus Macarthuri* instead of "Paddy River Box."

In restricted areas no doubt the common names for Eucalyptus trees do have some utility, because the number of distinct species in any one district is limited, but it is when local names found useful for discriminative purposes in one district are applied to altogether different trees growing in quite another locality that grave mistakes occur.

Most of the scientific names as applied to Eucalyptus species are not difficult for the commercial man to learn, and our experience has shown that their employment in commerce has considerable advantages. It is now customary with the larger manufacturers of Eucalyptus oils to indicate the origin of their products by using the scientific names, and not the vernacular, and even the small distiller in the "bush" has become familiar with the botanical name of the species he is working, and employs it for purposes of trade, for the reason that purchasers of oil prefer now to buy only on scientific names. In this way the article produced is easy to control, because the scientific name not only becomes distinctive for the tree, but means a standard for the product also, the economics for any individual species being so well defined.

It is thus evident that if the scientific name for any particular Eucalypt is utilised that the economics will be such that no difficulty or misunderstanding can arise either to the manufacturer or to the purchaser.

In this second edition of the work, therefore, the scientific names for the species are again emphasised, as the economic advantages to be derived by following this method are so great.

## Geographical Distribution.

THE scheme of evolution of the Eucalypts formulated in the following article is further supported by following out the geographical distribution of the species.

Thus on the assumption that those Eucalypts known as the "Bloodwoods," and their affinities are the oldest group of these trees, and that Western Australia is the oldest portion of the continent, one would naturally expect to find them well represented in that part of the continent, and such is the case. The "Bloodwoods," and red-timbered Eucalypts especially, are the distinguishing features of the forest trees belonging to the Genus in Western and North-western Australia, and trees with these characters extend through the Northern Territory down Eastern Queensland, and Eastern New South Wales, discontinuing in the north-east corner of Victoria, there being no representative of this group in Tasmania, where only pale coloured timbers occur.

The closely allied Genus *Angophora* accompanies the red-timbered Eucalypts in Queensland, down through New South Wales, finishing with one species, *Angophora intermedia*, on the Grampians, in Victoria. No *Angophora* species has been recorded from Tasmania, and no red wood Eucalyptus, either, for the matter of that—a pale timber feature that extends well into Victoria. Pale-coloured timbers also extend north, far into New South Wales. In this latter State we find in addition to the red woods, the groups of "Peppermints," "Stringybarks," and "Gums," gradually increase in number and importance as one travels south to Victoria, until in Tasmania they are the only representatives of the genus—the red woods and "Bloodwoods" being quite absent.

Branching off at different intervals from the main line of species are the "Ironbarks," "Gums," "Boxes," "Mallees," "Stringybarks," and "Peppermints." The "Ironbarks" are an interesting group, and evidently are closely connected with the members which yield oils richest in cineol.

Not only do we thus find an evolutionary agreement with the geology and botany, but this is further confirmed by the chemistry, for according to the above reasoning the more recent of the species shown at the end of our table, are found to yield phellandrene-bearing oils, while with the most ancient species occurring at the beginning of the table the terpene is pinene.

Thus applying the table of evolution to a contour map of Australia in the order of geological age, the head or primary species (the red woods) are found in the western portion of the continent, and then travelling north and south, complete the range with the pale-coloured timbers in Tasmania and Southern Victoria.



## The Probable Evolution of the Eucalypts.

PERHAPS one of the most interesting results brought to light by what appears to us the natural system of classification here adopted, is the affinity shown to exist between the members of the several groups of Eucalypts in their morphological and other physical characters, chemical constituents, venation of their leaves, and the nature of their barks and timbers. And not only is this affinity shown between the species of this important genus, but a close connection is also found to be well marked between *Eucalyptus* and the cognate genus *Angophora*, which, therefore, appears to us to be more closely connected to the former—both morphologically and chemically—than does the allied genus *Tristania*.

Since the above was written in 1902, Dr. Cuthbert Hall has published in the Proceedings of the Linnean Society, N.S.W., 1914, and in the Report of the British Association, 1915, the results of his work on the seedlings and cotyledons of a large number of Eucalypts. Photographs are also given. He there shows the close affinity of these two genera in the following words:—“The original Eucalypts represented now by those of the *E. corymbosa* class had large entire reniform cotyledons; these are practically identical with those of the nearly-related genus *Angophora*.”

If we deal with the affinity between the *Angophoras* and the *Eucalypts*, it will be found that the former have apparently only one feature—the absence of a calycine lid—which removes them generically from the Genus *Eucalyptus*. Some Eucalypts, however, show a tendency seemingly to develop petals, for in the case of *E. tetradonta*, F.v.M., *E. terminalis*, F.v.M., *E. tessellaris*, F.v.M., and a few others, it is found that the calyx is irregularly ruptured, rather than circumcised by a clearly-defined sutural line; for, as stated by Baron von Mueller in his “Eucalyptographia,” under *E. tetradonta*, “the strongly-toothed calyx demonstrates some transit towards *Angophora*, although the lid is in no way dissolved into petals as in that genus.”

In continuing this connection between these genera, it will be noted that in the nature of the bark, timber, calyx tube, inflorescence, kinos, and particularly in the chemical constituents of the oil, and venation of the leaves, the alliance between certain species is very striking.

The oils yielded by those Eucalypts known vernacularly as “Bloodwoods,” such as *E. calophylla*, *E. corymbosa*, *E. trachyphloia*, *E. eximia*, &c., and the allied species, *E. botryoides*, &c., invariably contain a large proportion of pinene; phellandrene is always absent, and cineol only occurs in traces, if at all.

The venation of the lanceolate leaves of all this group of species was found to correspond with that of the leaves of the *Angophoras*, and this feature is illustrated in plates I, II, and III.

It was this affinity in venation which first led us to inquire if the oils were also in agreement. For this purpose oil was distilled from the leaves of

*Angophora lanceolata*, Cav., and was found to contain identical constituents to those obtained from the "Bloodwoods" just mentioned. The sesquiterpene (aromadendrene) which occurs in some quantity in all this group of Eucalypts, was also present in the oil of *Angophora lanceolata*, as it gave the characteristic colour reaction for that constituent with bromine. (For the essential oils of the *Angophoras*, see paper by one of us, Roy. Soc., N.S.W., Aug., 1913.)

In August, 1896, a paper was read by one of us (Roy. Soc., N.S.W.) on a crystalline substance obtained from the exudation, or kino, of the "Red Gum" (*E. calophylla*), sent to the Museum by the Bureau of Agriculture, Western Australia; this substance was named aromadendrin. In the description of a new *Angophora* (*A. melanoxylon*), by one of us (Proc. Linn. Soc., N.S.W., 1900), the announcement was made that the kino of this tree contained aromadendrin, it being chemically identical with that described from *E. calophylla*. The chemical evidence relating to the affinity of these genera which has since accumulated, shows the connection to be somewhat complete.

Assuming the *Angophora* to be the older genus, we have endeavoured to formulate, on data similar to the above, a table or "tree," showing the supposed line of origin of the various groups of Eucalypts from the apparent initiation of the Genus. The table will be found at the end of this article, and a map of Australia indicating more fully the territorial distribution in connection with this evolution table is also added. The table includes the majority of the species of Eastern and Southern Australia, but when those of Northern and Western Australia shall have been more fully investigated on similar lines, a more complete tabulation will be possible, as then, no doubt, many of the connecting links which are at present felt to be wanting, will be forthcoming. We do not think that the investigation of those species will interfere materially with the main principle of evolution as here laid down.

Proceeding from the "Bloodwoods," it is possible, from the evidence available, that the line of descent was through *E. saligna* and *E. botryoides*, the venations (plate III), together with the chemical constituents of the oils, being very closely allied to those of the "Bloodwoods." In the oil of *E. saligna* cineol is making its appearance, for, although present but in small amount, it could be detected quite satisfactorily.

If botanical features are considered in conjunction with those of the chemical, it is seen that as the characteristic constituents of the oils vary in amount and change their character, so do the trees form well-defined groups.

For instance those seceding from the "Bloodwoods" apparently pass in three directions, one through the "Stringybarks" to the group of "Peppermints," another through the "Ironbarks" to that large group which includes the cineol-pinene oils generally, or those in which the terpene phellandrene is absent, and thirdly through one section of the "Stringybarks"—particularly *E. obliqua*—to the other large group which includes the typical "Boxes" and their associated "Mallees." The Genus may thus be considered as embracing four large groups which may be indicated, chemically, as follows:—

- (a) Those yielding oils consisting largely of the terpene pinene; either dextro-rotatory or lævo-rotatory.
- (b) Those yielding oils containing varying amounts of pinene and cineol, but in which phellandrene is absent.
- (c) Those yielding oils in which aromadendral is a characteristic constituent, and phellandrene usually absent.
- (d) Those yielding oils in which the terpene phellandrene is a pronounced constituent, with piperitone mostly present.



Of course connecting species and sub-groups link up the larger groups above, and such connections are indicated throughout this work by the system of classification adopted.

The suggestion that the line of sequence is through *E. saligna* and *E. botryoides* to the "Ironbarks" was indicated, not only by the chemistry of their oils, but also by that of their kinos; the richer cineol oils also show an association with the "Ironbarks," particularly through that of *E. sideroxylon*, and they are all grouped in this way to illustrate the sequence.

The greater number of the Eucalypts yield oils consisting largely of cineol and pinene in varying proportions, with an absence of phellandrene. It thus appears that phellandrene made its appearance late in the evolutionary arrangement of the genus, and if this is so then piperitone is quite a recent formation, even more so than the other characteristic constituent—aromadendral, which is also found in some West Australian species.

The suggestion that the "Boxes" and associated "Mallees" descended through the "Stringybarks" was derived from the oil of *E. obliqua*, a species with a most extensive range, the oil of which always contains aromadendral, and this characteristic constituent increased in amount as the typical "Boxes" were evolved.

A good many of the "Mallee" oils do not contain aromadendral, they being evidently more closely associated with the "Gums," and are here arranged in that manner. Such species are *E. Morrisii*, *E. pumila*, &c.

As the genus evolved the venation of the leaves and colour of the timbers changed in agreement with the alteration in the character of their oils. All the species belonging to the "Peppermints," the "Ashes," and associated species have white timbers, while in the earlier members they are usually red.

The genealogical table we now submit shows, in its general arrangement, the lines of sequence through which the Genus apparently evolved. Of course, it was not possible to depict diagrammatically, the most difficult sub-divisions which, to any student of the Eucalypts, must become apparent, but if the table is considered broadly, the general grouping will be evident, and this arrangement is supported by botanical as well as chemical evidence.

Passing onward from *E. pilularis* a well-defined group of trees is reached, the oils of which contain phellandrene as a pronounced constituent, and instead of aromadendral being present, this constituent has been replaced in these oils by the peppermint ketone, piperitone; consequently the leaves when crushed give an odour of peppermint, and for this reason the trees are generally known, vernacularly, as "Peppermints"; the more pronounced of these are *E. piperita*, *E. dives*, *E. amygdalina*, *E. vitrea*, &c. When the first Eucalyptus oil was distilled in Sydney in 1788 the leaves utilised were those of *E. piperita*, known locally as "Peppermint," so that the first-named species from New South Wales owes both its vernacular and specific names to the presence of this chemical constituent in the oil; and the introduction of the utilisation of chemical constituents in aiding the diagnosis of Eucalyptus trees dates as far back as the foundation of Australia. Results of recent investigations show that the value for determinative purposes of chemical constituents in the tree, as adopted by those early naturalists, was on a sound basis, and in the light of our present knowledge this determination is recognised as being of the greatest value in deciding differences between Eucalyptus trees which are morphologically closely allied.

It will be seen from plates VI, VII, and VIII that the venation of the leaves of trees giving phellandrene-bearing oils has an acute spreading arrangement inclining to run parallel to the mid-rib, which appears to be the completion of

the gradual alteration of the leaf venation of the Genus, which commenced with those species closely associated with the *Angophoras*. Piperitone is usually associated with phellandrene in the oils of species showing this venation, although its occurrence in some of them could not be decided with certainty: but it is probable that many of the constituents found in these oils are present in traces in many of them. Pinene, also, probably runs through the whole series, of course, diminishing more and more as it is replaced by phellandrene or other terpenes. Phellandrene appears to be present in a maximum amount in the oils of *E. dives*, *E. Andrewsii*, *E. radiata*, &c., and these species show very clearly the characteristic venation for this group. In the lanceolate leaves of these species, too, the marginal vein has receded so far from the edge that often a second one has commenced to form. In the leaves of this group, the reticulations between the more prominent veins in the leaves belonging to the cineol-pinene group have become still more subordinate, and consequently more room is given for the formation of oil glands, and thus the yields of oil from many species of this group are large. The black dots in the photographs show the position of the innumerable oil glands in the leaves. The reproduction of the venation can be carried out very successfully by photography, the fresh leaves being used. These are printed directly upon the paper in strong sunlight, and the prints thus obtained can be reproduced by any of the well-known photographic methods.

In October, 1901, we read a paper on this subject before the Royal Society of New South Wales, and demonstrated this alteration of leaf venation in agreement with the chemical constituents, by the aid of a series of lantern slides made from the photographs taken directly from the leaves; the completeness of these can be judged from the reproduction of the leaves in the illustrations (plates I to VIII).

In other parts of this work we show that this alteration in leaf venation and chemical constituents is not local in its incidence, and that the specific characters of each species are practically constant over the whole range of its distribution, and numerous instances are given of this constancy. It can thus be supposed that the formation of the several species of *Eucalyptus* has been one of evolution, and that the alteration in the chemical constituents of the oil has been contemporaneous with the changing of the leaf venation. It is thus assumed that the several species, as we know them to-day, have gradually deviated from a progenitor, and we have attempted to show through which channels this deviation has taken place. That the constituents of the oil have been fixed and constant for a long period of time must be evident by the fact that, to whatever extent or range any particular species has reached, it contains the same characteristic constituents, and has its botanical characters in agreement. This evidence is of the greatest importance when the length of time is considered which must necessarily have elapsed, before any one species could have established itself over such an extensive area as found to exist to-day. Some *Eucalypts*, however, appear to possess botanical and chemical characters which give them an affinity with one or two particular species only, whilst a few seem to have no pronounced connecting features, and, therefore, appear to stand quite alone; such species are thus not easy to place in a regular line of sequence, as though there were a complete gradation passing from one species to another. The intermediate forms, therefore, seem to be wanting in several instances, which may, perhaps, be largely accounted for by their extinction, or due to mutation.

The long period of quietude or comparative stability of terrestrial conditions in Australia probably accounts for the few indefinite varieties of *Eucalypts* that we have met with, and the environment also, having undergone little change,



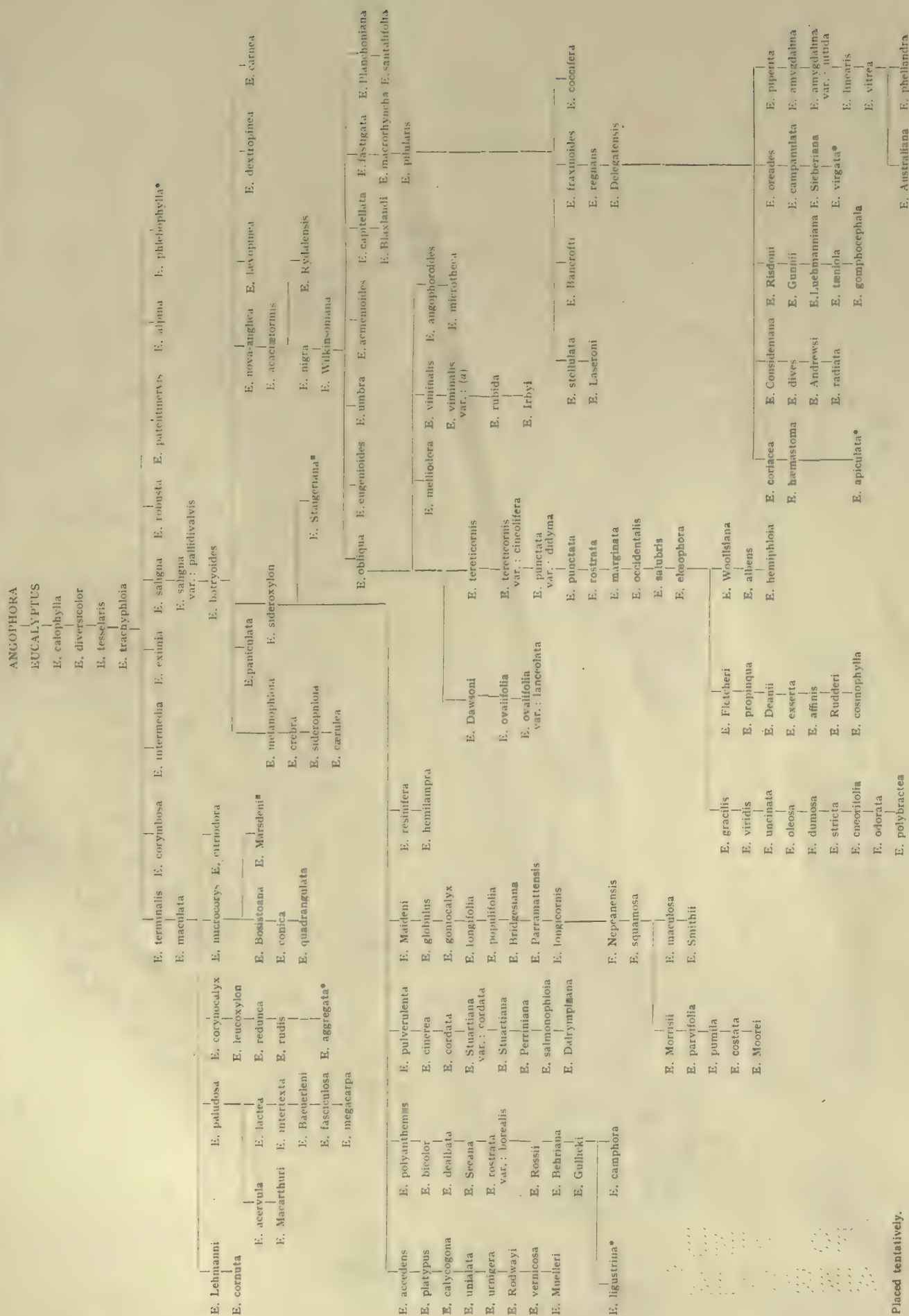
has produced a definiteness of species previously unsuspected in this Genus. This stability is illustrated in a most striking manner by the associations between the Tasmanian species and those of the mainland.

Such, then, are our views of the probable evolution of the Eucalypts, founded, as they are, on the broad basis of the natural classification previously enunciated.

Necessarily, our conclusions cannot always be expected to coincide with those who have classified on morphological grounds alone so wonderful a Genus as the Eucalypts—trees that will in the future be more fully appreciated, and more highly prized in Australia than they are at the present day.

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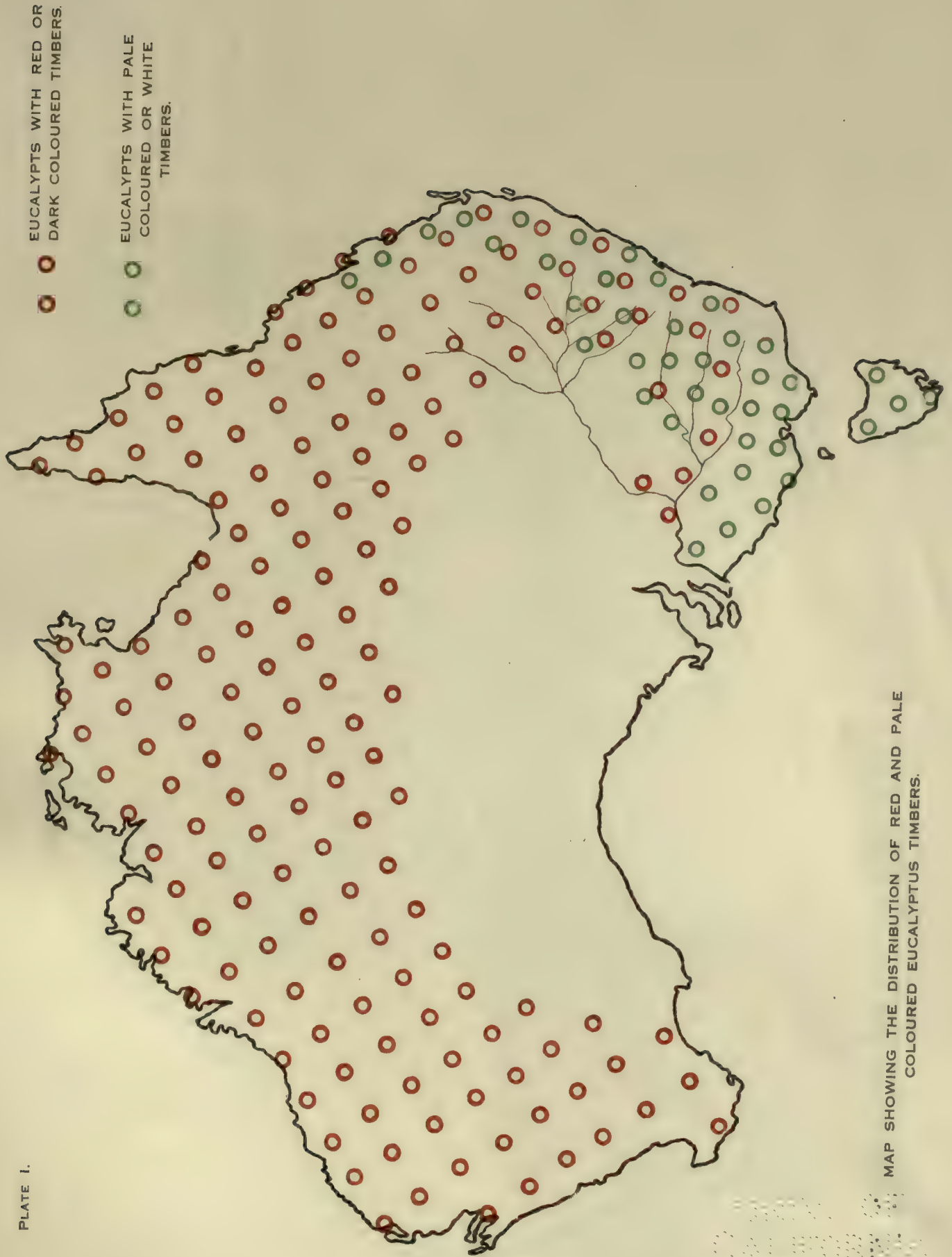
THIS DIAGRAM IS THE RESULT OF THIS RESEARCH, AND IS AN ATTEMPT TO SHOW THE PROBABLE EVOLUTION OF THE EUCALYPTS\*AS EVIDENCED BY THEIR BOTANICAL AND CHEMICAL CHARACTERS.



\* Placed tentatively.







MAP SHOWING THE DISTRIBUTION OF RED AND PALE  
COLOURED EUCALYPTUS TIMBERS.







MAP SHOWING APPROXIMATELY THE GEOGRAPHICAL LIMITATION OF EUCALYPTUS SPECIES ACCORDING TO THE MAIN CHEMICAL CONSTITUENTS IN THEIR OILS.







M. E. C. (1911)

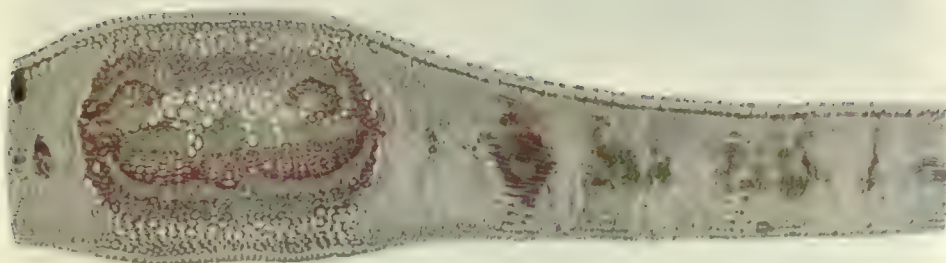
Nature, 1911

LEAF OF ANGOPHORA LANCEOLATA. CAV.

The venation indicates close affinity with those Eucalypts belonging to that end of the genus the leaves of which have a similar venation.







Transverse section through a leaf showing mid-rib (on the left) and portions of the leaf in proximity to it. *Angophoras* are comparatively free of oil glands and none was seen in the original section. The supporting tissue of the mid-rib is a conspicuous feature. The xylem of the mid-rib or vascular bundle is surrounded by phloem, so that it is bicollateral in this case. Palisade tissue is developed towards the upper side only, thus showing a great resemblance in this respect to *E. corymbosa*, and adding more weight to the evolutionary hypothesis advanced in this work.

ANGOPHORA LANCEOLATA, CAV.













M. J. C. 1917

Acad. Sci.

LEAF OF EUCALYPTUS BOTRYOIDES, SM.

The venation indicates the presence of pinene in the oil, and shows the commencement of the definition of certain lateral veins, which feature becomes more characteristic in the venation of those leaves belonging to the cineol-pinene group, as *E. globulus* L.







*Eucalyptus globulus*

*Eucalyptus globulus*

LEAF OF EUCALYPTUS GLOBULUS, LABILL.

The venation indicates that the oil contains cineol together with  
pinene and that phellandrene is absent.







M. F. Council, Photo.

Natural Size.

**LEAF OF EUCALYPTUS SMITHII. R.T.B.**

The venation indicates that the oil contains cineol together with pinene, and that phellandrene is absent.

Oils from Eucalyptus species having this leaf venation are extensively used for pharmaceutical purposes.







*M. J. C. C. C. C.*

*M. J. C. C. C.*

LEAF OF EUCALYPTUS SIEBERIANA. F.v.M.

The venation indicates a predominance of phellandrene in the oil, together with the peppermint ketone.







M. F. C. P.

Y. P. S.

LEAF OF EUCALYPTUS AUSTRALIANA. R.T.B. & H.G.S.

The innumerable oil glands shown in this leaf account for the abundance of oil obtained from this species.







M. J. Cooke. *Feet.*

LEAF OF EUCALYPTUS DIVES. SCHAU.

The venation indicates the presence of phellandrene in the oil together with the peppermint ketone. Note the characteristic looping arrangement of the principal veins, the commencement of which feature is first seen in the bending of the marginal vein in the venation of the leaves belonging to the cineol-pinene group. Oils obtained from Eucalyptus species having this leaf venation are now extensively used for the separation of metallic sulphides by a flotation process.



PART II.

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BOTANY, AND CHEMISTRY  
OF THE ESSENTIAL OILS  
OF THE SPECIES.

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The Sequence of the Species is based on both Botanical and Chemical Results.







# Eucalyptus Species Investigated.

## GROUP I.

- 1 *Eucalyptus calophylla*
- 2 *E. diversicola*
- 3 *E. tessellata*
- 4 *E. trachyphloia*
- 5 *E. terminalis*
- 6 *E. corymbosa*
- 7 *E. intermedia*
- 8 *E. eximia*
- 9 *E. botryoides*
- 10 *E. robusta*
- 11 *E. saligna*
- 12 *E. saligna* var.  
    *pathidivata*
- 13 *E. nova-anglicae*
- 14 *E. acaciiformis*
- 15 *E. Rydalenis*
- 16 *E. carnea*
- 17 *E. dextropinea*
- 18 *E. nigra*
- 19 *E. leopinea*
- 20 *E. phlebophylla*
- 21 *E. alpina*

## GROUP II.

- 22 *Eucalyptus Wilkinsiana*
- 23 *E. eugenoides*
- 24 *E. umbra*
- 25 *E. santalifolia*
- 26 *E. Blaxlandi*
- 27 *E. microcorys*
- 28 *E. hemilampina*
- 29 *E. corynotelyx*
- 30 *E. fasciculosa*
- 31 *E. megacarpa*
- 32 *E. redunca*
- 33 *E. Lehmanni*
- 34 *E. leucocylon*
- 35 *E. rudis*
- 36 *E. maculata*
- 37 *E. intertexta*
- 38 *E. lactea*
- 39 *E. pulchra*
- 40 *E. Baccarini*
- 41 *E. viminalis* var. *a.*
- 42 *E. paniculata*
- 43 *E. comuta*
- 44 *E. quadrangulata*
- 45 *E. conica*
- 46 *E. Bosistoana*

## GROUP III.

### CLASS (a).

- 47 *Eucalyptus polyanthemus*
- 48 *E. Stuartiana*
- 49 *E. Stuartiana* var.  
    *cordata*
- 50 *E. bicolor*
- 51 *E. longifolia*
- 52 *E. Behriana*
- 53 *E. Rossii*
- 54 *E. salmonophloia*
- 55 *E. Seeana*
- 56 *E. rostrata* var.  
    *borealis*
- 57 *E. camphora*
- 58 *E. Maidenii*
- 59 *E. Rodwayi*
- 60 *E. cinerea*
- 61 *E. dealbata*
- 62 *E. resinifera*
- 63 *E. accedens*

- 64 *Eucalyptus cernicea*
- 65 *E. urnigera*
- 66 *E. unilata*
- 67 *E. Gulliveri*
- 68 *E. platypus*
- 69 *E. calycogona*
- 70 *E. Dalrympleana*

### CLASS (b).

- 71 *Eucalyptus subcylindrica*
- 72 *E. squameosa*
- 73 *E. Smithii*
- 74 *E. Ingleiana*
- 75 *E. populifolia*
- 76 *E. Parramattensis*
- 77 *E. parvifolia*
- 78 *E. punctata*
- 79 *E. pulcherrima*
- 80 *E. Alcockii*
- 81 *E. Alcockii*
- 82 *E. Muellarii*
- 83 *E. longicornis*
- 84 *E. Parmaniana*
- 85 *E. costata*
- 86 *E. maculosa*
- 87 *E. gomocalyx*
- 88 *E. glabrus*
- 89 *E. N. paucis*
- 90 *E. cordata*
- 91 *E. Australiana*

## GROUP IV.

### CLASS (a).

- 92 *Eucalyptus cheopora*
- 93 *E. punctata*
- 94 *E. tereticornis* var.  
    *cinclifera*
- 95 *E. cosmophylla*
- 96 *E. stricta*
- 97 *E. oleosa*
- 98 *E. dumosa*
- 99 *E. polybractea*
- 100 *E. cuneifolia*
- 101 *E. odorata*

### CLASS (b).

- 102 *Eucalyptus melliodora*
- 103 *E. ovalifolia* var.  
    *lanceolata*
- 104 *E. Considmaria*
- 105 *E. Risdoni*
- 106 *E. linearis*

## GROUP V.

- 107 *Eucalyptus tereticornis*
- 108 *E. punctata* var.  
    *didyma*
- 109 *E. rostrata*
- 110 *E. propinqua*
- 111 *E. Deanii*
- 112 *E. Rudderi*
- 113 *E. salubris*
- 114 *E. occidentalis*
- 115 *E. exserta*
- 116 *E. marginata*
- 117 *E. affinis*
- 118 *E. Fletchei*
- 119 *E. Woollsiana*
- 120 *E. albens*
- 121 *E. hemiphloia*
- 122 *E. gracilis*
- 123 *E. aridis*
- 124 *E. uncinata*

## GROUP VI.

- 125 *Eucalyptus viminalis*
- 126 *E. Cinnamomi*
- 127 *E. rubida*
- 128 *E. Liby*
- 129 *E. Bancrofti*
- 130 *E. acervula*
- 131 *E. haemastoma*
- 132 *E. Lascroni*
- 133 *E. ovalifolia*
- 134 *E. Dawsoni*
- 135 *E. angophoroides*
- 136 *E. microtheca*
- 137 *E. fastigata*
- 138 *E. fraxinoides*
- 139 *E. macrohyncha*
- 140 *E. capitellata*
- 141 *E. acmenoides*
- 142 *E. Planchoniana*
- 143 *E. pilularis*
- 144 *E. obliqua*
- 145 *E. crebra*
- 146 *E. siderophloia*
- 147 *E. melanophloia*
- 148 *E. cerulea*

## GROUP VII.

### CLASS (a).

- 149 *Eucalyptus piperita*
- 150 *E. amygdalina*
- 151 *E. amygdalina* var.  
    *nitida*
- 152 *E. phellandra*
- 153 *E. vitrea*
- 154 *E. Lehmammiana*
- 155 *E. coccifera*

### CLASS (b).

- 156 *Eucalyptus coriacea*
- 157 *E. Stebriana*
- 158 *E. campanulata*
- 159 *E. oreades*
- 160 *E. delegatensis*
- 161 *E. regnans*
- 162 *E. gomphoccephala*
- 163 *E. terniola*
- 164 *E. Andrieuxi*
- 165 *E. dives*
- 166 *E. radiata*

## GROUP VIII.

- 167 *Eucalyptus virgata*
- 168 *E. stellulata*
- 169 *E. Macarthuri*
- 170 *E. aggregata*
- 171 *E. Staigeriana*
- 172 *E. patentinervis*
- 173 *E. citriodora*
- 174 *E. Marsdeni*
- 175 *E. ligustrina*
- 176 *E. apiculata*

## ADDENDUM.

- 177 *Eucalyptus Baileyana*
- 178 *E. obtusiflora*

## GROUP I.

In this Group are placed the following EUCALYPTS yielding an oil consisting largely of Pinene, without phellandrene. Cineol is almost or quite absent.

1. *Eucalyptus calophylla.*
2. *E. diversicolor.*
3. *E. tessellaris.*
4. *E. trachyphloia.*
5. *E. terminalis.*
6. *E. corymbosa.*
7. *E. intermedia.*
8. *E. eximia.*
9. *E. botryoides.*
10. *E. robusta.\**
11. *E. saligna.*
12. *E. saligna, var. pallidivalvis.*
13. *E. nova-anglica.\**
14. *E. acaciæformis.*
15. *E. Rydalsensis.*
16. *E. carnea.*
17. *E. dextropinea.*
18. *E. nigra.*
19. *E. lævopinea.*
20. *E. phlebophylla.*
21. *E. alpina.*

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\* In the oil of this species traces of phellandrene were detected, nevertheless it is practically a pinene oil, so has been placed in this group.





*EUCALYPTUS CALOPHYLLA*, R.Br.  
RED GUM OF WESTERN AUSTRALIA.



## 1. *Eucalyptus calophylla*.

(R.Br., in Journal Geographical Soc., 1831, 20. Schau., in Pl. Preiss., i, 131.)

Red Gum.

**Systematic.**—One of the largest trees of Western Australia, with a rough bark, shortly fibred, and irregularly furrowed and broken. Leaves ovate-lanceolate, shortly acuminate; the venation distinct, lateral veins are nearly transverse and closely parallel, the intramarginal vein almost touching the edge. The flowers, red or white, form a terminal corymb or panicle, and are comparatively large. The calyx is pear-shaped, about  $\frac{1}{2}$  inch long; the operculum being quite depressed.

**\*Fruit.**—Large, on a pedicel nearly 1 inch long, urn shaped, occasionally ribbed, contracted at the orifice; rim well counter-sunk; valves deeply sunk; about  $1\frac{1}{4}$  inch long and 1 inch broad.

*This fruit is typical in shape of the "Bloodwood" group and probably the largest of that section, the size easily differentiating it from its congeners, except, perhaps, E. Planchoniana and E. ficifolia, both of which it closely resembles.*



**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for oil distillation were forwarded to the Museum from the Darling Range, Western Australia, by the Agricultural Department of that State, and the results were published in the Pharmaceutical Journal, September, 1905. The yield of oil was 0.25 per cent. The crude oil was of a dark red colour, and had a turpentine-like odour, with little resemblance to that of ordinary Eucalyptus oils. It consisted largely of pinene, which was mostly dextro-rotatory. The third fraction contained a considerable amount of cymene, judged by the odour and physical properties. Cymene has been proved to occur in the oils belonging to this class of Eucalypts, but sufficient of this oil could not be spared to provide chemical proof. The sesquiterpene occurs in considerable amount, as proved by the reactions, and 10 per cent. of the oil distilled above  $245^{\circ}$  C. Phellandrene was not detected, and cineol only in traces in the portion distilling about  $176^{\circ}$  C. Constituents boiling between  $185^{\circ}$  and  $245^{\circ}$  C. were practically absent, as only two or three drops came over between those temperatures, so that aromadendral and piperitone do not occur. The comparative insolubility in alcohol also showed the oil to contain a large excess of terpenes. The dark colour of the oil was readily removed by agitating with dilute aqueous soda. The esters easily saponified in the cold, while at a high temperature they decomposed; the principal ester was evidently geranyl-acetate.

\* The illustrations of the fruits are all drawn to NATURAL SIZE, which, of course, may vary somewhat but the general contour will be found to be fairly constant.



The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.8756$ ; rotation  $a_D + 22.9^{\circ}$ ; refractive index at  $20^{\circ} = 1.4731$ , and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 10.5.

On rectification the following four fractions were obtained :—

Between  $159\text{--}162^{\circ}\text{C.}$ , 37 per cent. distilled; between  $162\text{--}172^{\circ}$ , 32 per cent. came over; between  $172\text{--}245^{\circ}$ , 13 per cent. distilled, and between  $245\text{--}264^{\circ}$ , 10 per cent. distilled.

These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.8619$ ; rotation  $a_D + 33.4^{\circ}$ .

Second " " " " =  $0.8616$ ; " " " " +  $29.4^{\circ}$ .

Third " " " " =  $0.8650$ ; " " " " +  $15.8^{\circ}$ .

Fourth " " " " =  $0.9254$ ; light did not pass well.

In a paper read by us before the Royal Society of New South Wales, October, 1901, "On the Relation between Leaf Venation and the Presence of Certain Chemical Constituents in the Oils of the Eucalypts," the following appears, page 117 :—

"We are not aware that the oil has yet been distilled from the leaves of *E. calophylla*, but from the chemical evidence and the botanical characteristics of leaf venation, it is very probable that when distilled, pinene will be found to be an important constituent of the oil, and that phellandrene will be absent."

This was in relation to a species growing 3,000 miles away.

The results of this investigation bear out the correctness of that surmise, which was, of course, based upon the facts obtained during the investigation, for the first edition, of a very large number of species of *Eucalyptus*. From the numerous confirmatory results obtained since that paper was written (and later with the kinos) it appears that there is a very close relationship, not only between the botanical characters, but also the chemical constituents of the various species of *Eucalyptus*, belonging to this group.

## 2. *Eucalyptus diversicolor*.

(F.v.M., in Frag. iii, 131, 1863.)

Karri.

**Systematic.**—This tree is the largest in Australia, even attaining a height of 400 feet, and thus exceeding any other *Eucalyptus* on the Continent. The bark may be described as persistent, whitish, or in older trees blackish and decorticating in long strips. \*Abnormal leaves are ovate or oval in shape, the normal ones being lanceolate, acuminate, falcate; both kinds having a pale under-surface. The veins are very numerous, not pronounced, but spreading

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\* It has been customary in the past to speak and write of these particular leaves as "Sucker" leaves, but as *Eucalyptus* trees do not "sucker" in the way defined in botanical works—that is, send forth shoots from the roots varying in distances from the stem—the term is discarded in this work, and the word abnormal used instead as it seems to more appropriately express nature's work in this direction, for science is not advanced by perpetuating such an apparent misnomer as "Sucker" leaves.

with a marginal one somewhat removed from the edge. The oil glands are fairly plentiful. The flowers are not numerous and occur in axillary peduncles, the calyx being elongated, and the operculum shortly acuminate.

**Fruit.**—Urn-shaped, contracted at top with a narrow groove, at outer edge of a counter-sunk rim; valves not exerted and running vertically from the base of the rim; 5 lines long and as broad.



*The smaller fruits are very similar to those of the Eastern Coastal species, E. pilularis.*

**Habitat.**—Western Australia.

**ESSENTIAL OIL.** The oil of this species was distilled by Mr. P. R. H. St. John, in January, 1917, from trees cultivated in Melbourne, Victoria, and forwarded to the Technological Museum for investigation. The yield of oil was equal to 1.1 per cent. The crude oil was of a lemon-yellow colour, and had a terpene-like odour, while that of volatile aldehydes was very pronounced. The principal constituent was dextro-rotatory pinene. Cineol was only present in very small amount. Esters were determined, the principal being butyl-butyrate in the lower boiling fraction, terpinyl-acetate and geranyl-acetate in the higher. Free geraniol and free terpineol were also present.

The crude oil had specific gravity at 15° C. = 0.8948; rotation  $\alpha_D + 20.5^\circ$ ; refractive index at 20° = 1.4671, and required 4 volumes 80 per cent. alcohol to form a clear solution. The saponification number for the esters and free acid was 50.7. In the cold with two hours' contact it was 11.3. After acetylation the saponification number was 101.5.

On rectification no less than 2 per cent. came over below 122° C. (corr.). Between 122–172°, 47 per cent. distilled; between 172–183°, 20 per cent. distilled, leaving a residue of 31 per cent. boiling above 183° C. These fractions and residue gave the following results:—

|                       |                                                                                                  |
|-----------------------|--------------------------------------------------------------------------------------------------|
| First large fraction, | sp. gr. at 15° C. = 0.8725; rotation $\alpha_D + 24.6^\circ$ ; refractive index at 20° = 1.4626. |
| Second                | “ “ “ “ = 0.8878; rotation $\alpha_D + 18.4^\circ$ ; refractive index at 20° = 1.4698.           |
| Residue               | “ “ “ “ = 0.9342; rotation $\alpha_D + 16.2^\circ$ ; refractive index at 20° = 1.4731.           |

The saponification number for the first fraction was 16.4; for the second, 31.4; and for the residue, 104.2. The ester in the first fraction was mostly butyl-butyrate.

The volatile acids of the several esters were determined in the usual way, by saponification, formation of the barium salt, and decomposing this with sulphuric acid. The barium salt gave 88.12 per cent. barium sulphate, equal to 80.2 per cent. barium acetate, and 19.8 per cent. barium butyrate. The odour of butyric acid was pronounced during the reaction.

A portion of the crude oil was distilled, and all below 190° C. removed, this equalled 68 per cent. The higher boiling portion had saponification number 129.7, while in the cold with two hours' contact it was 34.2. The whole was then saponified by boiling with alcoholic potash, the aqueous portion separated, and the oil thoroughly washed. It was then distilled at 10 millimetres pressure; most of it being obtained between 98–105° C. On again redistilling at the same



pressure the greater portion came over between 99–100° C. This had specific gravity at 15° C. = 0.940; rotation  $a_D + 21.5^\circ$ ; refractive index at 20° = 1.4831, and gave a good yield of phenyl-urethane, melting at 111° C.

It is thus evident that the principal alcohol in the oil of this species is dextro-rotatory terpineol, and by inference that of other associated species also. As terpineol has been isolated from the oils of the "Peppermint" group, it is evident that this alcohol as well as geraniol runs through the whole genus.

The acids in the aqueous portion were determined in the usual way. The result was 86.94 per cent. barium acetate and 13.06 barium butyrate. This again indicates that butyl-butyrate is the lower boiling ester in this oil.

A sample of the oil of this species was distilled by Mr. Braddock in West Australia, in October, 1918, and forwarded to the Museum by Mr. C. E. Lane Poole, the Conservator of Forests for that State. The oil was a little heavier than the previous sample and had apparently been distilled longer, it also contained a little more cineol, otherwise the general trend of results is similar.

The crude oil had specific gravity at 15° C. = 0.9083; rotation  $a_D + 20.5^\circ$ ; refractive index at 20° = 1.4748.

The saponification number for the esters and free acid was 41 by heating, and 14.7 in the cold with two hours' contact.

The range of saponification number was 11.6 for the first fraction, 27.8 for the second fraction, and 100 for the third fraction.

A portion of the crude oil was acetylated, when the saponification number had risen to 83.8; while in the cold with two hours' contact it was 50.0, thus indicating geraniol as the alcohol, particularly as the odour of the separated oil was distinctly that of geraniol. The acids from all the saponifications were separated, purified, and determined in the usual way, the result being 66.8 per cent. barium acetate, and 33.2 per cent. barium butyrate.

The original determination of the oil of this species was published by us in the *Pharmaceutical Journal*, September, 1905. Taken as a whole the results agree very well with those now recorded, as is shown by the following:—Material sent from Karridale, Western Australia, in January, 1904. The yield of oil was 0.83 per cent. The crude oil was light-lemon yellow in colour, and had a terpene-like odour. The oil consisted largely of dextro-rotatory pinene. Phellandrene was absent and cineol only present in very small amount. The specific gravity at 15° C. = 0.9145; rotation  $a_D + 30.1^\circ$ ; refractive index at 20° = 1.4727, and was soluble in one volume 80 per cent. alcohol. The saponification number for the esters and free acid was 53.2.

### 3. *Eucalyptus tessellaris*.

(F.v.M., in Jour. Linn. Soc., iii, 88.)

**Moreton Bay Ash or Carbeen.**

**Systematic.**—A tall tree, with a persistent, tessellated bark on the lower trunk, branches smooth. Leaves thin and narrow, lanceolate, with numerous fine, parallel, not prominent veins, the intramarginal vein close to the edge. Oil glands rare. Peduncles very short, usually several together in lateral clusters



or very short panicles, often so reduced as to appear like a single, compact, irregular umbel, each peduncle with three to six flowers on short slender pedicels. Calyx oblong, 3 lines long; operculum shortly domed.

**Fruit.**—Cylindrical or urn-shaped; rim rounded or thick, the capsule sunk; 3 to 6 lines long and 3 to 4 lines broad.

*The fruits of this species are almost identical in shape and size with those of E. trachyphloia, but with a thicker rim.*



**Habitat.**—New South Wales and Queensland.

**REMARKS.**—The timber is of excellent quality, and the tree is remarkable for its drought-resisting qualities. The tessellated nature of the bark gives character to the species in the field. The leaves of this species are greedily eaten by sheep, and the trees are consequently pollarded or cut down for fodder. "Carbeen" has a dark blue bark, whilst *E. trachyphloia* is a pale yellow in colour. The leaves of this species are much narrower than those of *E. trachyphloia* and its timber is dark coloured, resembling Walnut (*Cryptocarya Palmerstoni*) or Black Bean (*Castanospermum australe*), and is equally as hard.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Narrabri, N.S.W., in July, 1901. The yield of oil was 0.16 per cent. The crude oil was of a dark colour, and had an odour, when diffused, strongly reminding of cymene. As the characteristic oxidation products of cymene were obtained with the oil of *E. melanophloia*, it is very probable that cymene is a constituent in the oil of the present species. Phellandrene does not occur; pinene was proved by its chemical combinations and reactions. A small quantity of cineol was found, but not exceeding 5 to 10 per cent. The presence of the sesquiterpene (aromadendrene) was pronounced. The dark colour of the oil was due to the phenols acting on the iron removed from the still by the action of the free acids in the oil. The colour was readily removed by agitating the oil with a dilute solution of soda; the remaining oil was then nearly colourless, so that the optical rotation could be readily taken. The venation of the mature lanceolate leaves of this species indicates the predominance of pinene in the lower boiling terpenes, thus being in agreement with the oils of the genus *Angophora*. (For the oils of the *Angophoras* see paper by one of us, Proc. Roy. Soc., N.S.W., Aug. 1913.)

The crude oil had specific gravity at 15° C. = 0.8757; optical rotation,  $\alpha_D + 8.6^\circ$ ; refractive index at 20° = 1.4824, and was not soluble in 10 volumes 80 per cent. alcohol.

On rectification a few drops of acid water with some aldehydes came over below 160° C. (corr.). Between 160–172° C., 47 per cent. distilled; between 172–214°, 34 per cent. came over; the boiling point then rapidly rose to 240°, between which temperature and 265°, 11 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.8642; rotation  $\alpha_D + 6.8^\circ$ .

Second " " " = 0.8673; " + 11.4°.

Third " " " = 0.9301; " to the right.

There is a constituent in the higher boiling portions which has a rotation to the right, but it was not isolated. The saponification number for the esters and free acids was 6.2. The volatile aldehydes were much less distinct in this oil, than in those belonging to the cineol group. The oil of this species is a terpene one, and of little commercial value.

## 4. *Eucalyptus trachyphloia*.

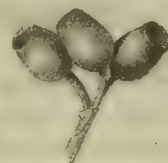
(F.v.M., in Jour. Linn. Soc., iii, 90.)

### A Bloodwood.

**Systematic.**—A tall tree, with a pale-yellowish, laminated, tessellated bark, quite unlike that of any other New South Wales species of *Eucalyptus*. Leaves lanceolate, acuminate, occasionally falcate, from 4 to 6 inches long; lateral veins fine, numerous, parallel, slightly more oblique than those of *E. corymbosa*, Sm.; intramarginal vein quite close to the edge. Flowers in terminal panicles, on slender pedicels. Calyx, bell-shaped, 2 to 3 lines long; ovary flat-topped; operculum short, obtuse.

**Fruit.**—Urn-shaped, not constricted below the rim, which is countersunk; 3 to 4 lines long, and 3 lines in diameter.

*They are somewhat similar in shape to those of E. tessellaris, F.v.M., but smaller, and with a sharper edge to the rim.*



**Habitat.**—Murrumbo Narrabri, New South Wales; Queensland.

**REMARKS.**—This tree is very easy of determination in the field by its yellow tessellated friable bark, stained in places by its freely exuding kino. It is rather limited in its distribution in New South Wales, where it was first recorded from Murrumbo, on the Goulburn River (R.T.B.), and at Narrabri. Both timber and bark somewhat resemble those of *E. eximia*, F.v.M., a coast "Bloodwood," the former being pale coloured, hard, and very durable. It is very foliaceous, although the leaves are rather small for so large a tree. Grows on sandstone country.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Murrumbo, N.S.W., in October, 1900. The yield of oil was 0.2 per cent. The crude oil was reddish in colour, and had an odour indicating turpentine at first, with a secondary one somewhat resembling cinnamon. The principal constituents in this oil were dextro-rotatory pinene and the sesquiterpene; the aldehyde aromadendral was also present, and this was indicated by the lævo-rotation of the fourth fraction. It was also extracted by sodium bisulphite from the third fraction, and its presence thus confirmed. Phellandrene was not found in this oil, and only a trace of cineol could be detected.

The crude oil had a specific gravity at 15° C. = 0.8929; optical rotation  $\alpha_D + 9.8^\circ$ ; refractive index at 20° = 1.4844, and was not soluble in 10 volumes 80 per cent. alcohol.

On rectification a few drops of acid water with some aldehydes came over below 162° (corr.). Between 162–172°, 44 per cent. distilled; between 172–183°, 16 per cent. came over; between 183–244° 5 per cent. distilled, and between 244–278°, 31 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.8616; rotation  $\alpha_D + 9.5^\circ$ .

Second " " " = 0.8668; " " " + 5.7°.

Fourth " " " = 0.9401; " " " — 0.4°.

The saponification number for the esters and free acid was 3.13.



Material of this species was also obtained from Narrabri, N.S.W., in July, 1901. The oil was practically identical with the above, the only noticeable difference being a less yield; but this is probably due to the leaves being collected in midwinter. The secondary odour had a strong resemblance to that of cinnamon. Yield of oil = 0.07 per cent. Specific gravity of crude oil = 0.8873 and optical rotation  $\alpha_D + 8.4^\circ$ . Cineol could not be detected, and phellandrene was absent. The presence of the sesquiterpene was indicated by its characteristic colour reactions.

## 5. *Eucalyptus terminalis*.

(F.v.M., in Jour. Linn. Soc., iii, 89.)

### A Bloodwood.

**Systematic.**—A fair-sized tree, with a brick-red, flaky bark. Leaves lanceolate mostly under 4 inches long, light yellow in colour, coriaceous; intra-marginal vein close to the edge; lateral veins numerous, fine, almost transverse, parallel. Oil glands appear to be quite absent. Umbels in a broad, terminal corymb. Calyx 3 lines long and 3 lines in diameter, bell-shaped, pedicels 3 lines long; operculum hemispherical, shortly acuminate.

**Fruit.**—Urn-shaped; rim countersunk; under 1 inch long, and up to 8 lines in diameter.

*Care is required, in some instances, not to confound the fruits with those of E. eximia and E. intermedia.*

**Habitat.**—The Northern interior of New South Wales; West Australia; South Australia; Queensland.



**REMARKS.**—This *Eucalyptus* tree closely resembles *E. eximia*, Schau., and *E. intermedia*, R.T.B., in the shape of the fruits and the nature of the timber and bark, but has paler and smaller leaves. Mueller and Benthams were inclined to regard it as a variety of *E. corymbosa*, Sm., but it differs from that species in fruit, timber and leaves. The scarcity of oil glands is a distinguishing feature in this, as in most of the "Bloodwoods." The leaves are thick and of a yellowish colour, probably being rich in the dye myrticoline.

**ESSENTIAL OIL.**—A quantity of leaves (60 lb.) was received from the far interior of New South Wales, but as the leaves showed an entire absence of oil glands, and other indications for oil were so unsatisfactory, no distillation was made. It is evident that several hundreds of pounds of material would be necessary in order to obtain sufficient oil to enable an investigation to be undertaken.



## 6. *Eucalyptus corymbosa*.

(Sm., in Bot. Nov. Holl. 43, and in Trans. Linn. Soc., iii, 287.)

### Bloodwood.

**Systematic.**—A tree not easily confounded with other species. It grows very tall. Bark persistent, furrowed, of a reddish colour, fibrous, but not stringy in the sense of the "Stringybarks," as it can be removed in flakes. The tree exudes kino very abundantly, the whole stem being sometimes covered with this reddish blood-like substance, and hence its vernacular name. Leaves lanceolate, slightly falcate, varying in size up to 9 inches long and 2 inches broad, pale on the underside; lateral veins very fine, and very numerous, only slightly oblique; intramarginal vein close to the edge. Oil dots not numerous. Peduncles many, mostly terminal, forming a large corymbose panicle. Buds nearly 1 inch long. Calyx conical, tapering into the pedicel; ovary flat-topped; operculum hemispherical, shortly acuminate.

**Fruit.**—More or less urn-shaped; rim countersunk; valves hidden below the base of the broad rim; 7 to 9 lines long, and 5 to 6 lines broad.

*Morphologically the fruits are distinct from any other species, the large reflected broad rim distinguishing it from its nearest congeners, E. intermedia and E. eximia.*

**Habitat.**—Coast and Dividing Range of New South Wales; Queensland; just a few trees occurring in the North-east corner of Victoria; North Australia.



**REMARKS.**—A common tree in the county of Cumberland, N.S.W., and appears never to have had but one common name, *i.e.*, that of "Bloodwood." It attains a height of over 100 feet in favourable situations, but near the coast (La Perouse) it is stunted in growth. The timber has a deep red fleshy colour, is porous, has numerous gum veins, and is regarded, notwithstanding these latter, as very durable in the ground when split tangentially, or, as bushmen term it, "to the shoulder." The "Bloodwood" (*E. intermedia*), R.T.B., of the Clarence and Richmond Rivers and Cambewarra (W.B.), has in the past been confounded with this species. The two, however, are distinct, as they differ in the shape of the fruits, bark, and timber. Both specimens are easy of determination. (*Vide* remarks under *E. intermedia*.)

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Gosford, N.S.W., in November, 1896. The yield of oil was very small—365 lb. of green material giving only 3½ ounces of oil, equal to 0.06 per cent.

The crude oil was of a light lemon colour, and had a turpentine-like odour, with a secondary one distinctly aromatic. The oil consisted largely of pinene; phellandrene could not be detected, and but a trace of cineol was present. Aromadendral was indicated by the second fraction having a higher rotation to the left than had the first fraction. The third fraction consisted largely of the sesquiterpene. Crystallised eudesmol was not found. The crude oil had specific gravity at 15° C. = 0.883; optical rotation  $\alpha_D$  — 8.4°; refractive index at 20° = 1.4838; and was not soluble in 10 volumes 80 per cent. alcohol.



*EUCALYPTUS CORYMBOSA*, SM.

BLOODWOOD.

70 1000  
1000000000





A TYPICAL BLOODWOOD BARK.

*Eucalyptus corymbosa*, Sm.

In this group of trees the bark is rough, rigid, reddish in colour, friable, and very short in the fibre, with medium furrows.

The oils of Eucalypts with barks of this character all contain the terpene pinene as an important constituent. Cineol is usually almost absent. The "Bloodwoods" are chiefly found in the first group and apparently represent the oldest species of the genus.

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Sections of the leaf taken in a similar position to that of the preceding, *Angophora lanceolata*. The Bloodwoods are perhaps the lowest yielders of an essential oil amongst Eucalypts, and so the oil glands are mostly wanting. It is worthy of note that the palisade layers are only developed on the upper surface, as in the *Angophoras*. This feature is characteristic of the leaves of the Bloodwood Group. The wood fibres surrounding the mid-rib are a conspicuous feature, as well as the ducts in the bundle, and the equal development of the xylem. X 35.

**EUCALYPTUS CORYMBOSA. SM.**

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On rectification the usual amount of acid water and volatile aldehydes came over below 160° C. (corr.). Between 160–172°, 54 per cent. distilled; between 172–245°, 22 per cent. came over; and between 245–270°, 14 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.8633; rotation  $a_D$  — 9.7°.

Second " " " = 0.8689; " " — 10.5°.

Third " " " = 0.9262; light did not pass.

The saponification number for the esters and free acid was 3.8.

The differences in the characters shown by the oils of the three "Bloodwoods"—*E. corymbosa*, *E. intermedia*, and *E. eximia*—are given in the following table:—

|                                                   | Specific Gravity at 15° C. Crude Oils. | Optical Rotation $a_D$ Crude Oils. | Yield of Oil per cent. | Saponification Number for Esters and Free Acids. |
|---------------------------------------------------|----------------------------------------|------------------------------------|------------------------|--------------------------------------------------|
| <i>E. corymbosa</i> , Gosford, November, 1896 ... | 0.883                                  | — 8.4                              | 0.06                   | 3.8                                              |
| <i>E. intermedia</i> , Lismore, October, 1900...  | 0.8829                                 | + 9.9                              | 0.125                  | 2.5                                              |
| <i>E. eximia</i> , Springwood, August, 1899...    | 0.8998                                 | + 28.8                             | 0.462                  | 4.5                                              |

## 7. *Eucalyptus intermedia*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 674.)

### A Bloodwood.

**Systematic.**—A medium-sized tree, with a light-brown flaky bark. Leaves lanceolate, acuminate, about 6 inches long, and 1 to 1½ inch wide or more, pale on the underside; lateral veins oblique, fine, numerous, parallel; intra-marginal vein quite close to the edge. Flowers mostly in large terminal corymbs; calyx turbinate, 4 lines in diameter, 3 lines long, on a pedicel of about 4 lines.

**Fruit.**—Urceolate, mottled, contracted at the orifice to sometimes 2 lines; rim countersunk, with a ringed edge; about 10 lines long, 5 to 7 lines in diameter.

*The fruits are not unlike those of E. corymbosa without the expanding neck.*



**Habitat.**—Richmond and Clarence Rivers to South Coast districts of New South Wales.

**Timber.**—A pale pink-coloured timber, hard, straight-grained, and easy to work. It is much closer in texture than the Sydney "Bloodwood" (*E. corymbosa*, Sm.). The figure is occasionally not unlike that of *E. maculata*, Hook.

Gum veins are often present. It is considered a good, durable timber, and superior to that of *E. corymbosa*, Sm. It has quite a metallic ring when the fractured edges of two pieces are rubbed together.

**REMARKS.**—A tree closely allied to both *E. corymbosa*, Sm., and *E. eximia*, Schau. It has, however, always been considered as the northern form of the former species, but in botanical characters it more nearly resembles the latter, and especially *E. maculata*, Hook. The chemical constituents and optical features place it midway between the two former. It differs from *E. corymbosa* in the nature of the timber, bark, oil, and fruits, which have not the marked recurved rim of that species. From *E. eximia* it differs in pedicellate fruits, a stringy, flaky bark, and its pinkish timber. Dr. Woolls was cognisant of the differences existing between these species, for in his "Flora of Australia" (p. 238) he states:—"At the Clarence and Richmond Rivers the 'Bloodwood' prevails to a great extent, and the workmen reckon two kinds—one with smooth, and the other with rough bark. It seems probable that the Mountain 'Bloodwood' (*E. eximia*), which overhangs the valley of the Grose, is different from the 'Bloodwood' of the north." Most botanists have regarded the northern "Bloodwood" as identical with the Sydney and southern "Bloodwood," but Dr. Woolls is the only one who connected it (the northern one) with *E. eximia*, Schau., and our recent observations also show it to have affinities with that species. Its physical characters however, are so evenly balanced between the two (*E. eximia* and *E. corymbosa*) that it was decided to give it specific rank.

**ESSENTIAL OIL.** Leaves and terminal branchlets for distillation were obtained from Lismore, N.S.W., in October, 1900. The yield of oil was 0.13 per cent. The crude oil was amber coloured, and had a slight aromatic odour. It consisted largely of pinene; phellandrene was not present, and but a trace of cineol could be detected.

The crude oil had a specific gravity at 15° C. = 0.8829; optical rotation  $a_D + 9.9^\circ$ ; refractive index at 20° = 1.4821, and was insoluble in 10 volumes 80 per cent. alcohol. The rotation of the higher boiling portion of the oil being to the left, indicated the presence of aromadendral, particularly as an aldehyde was shown to occur in this fraction. The saponification number for the esters and free acid was 2.5.

On rectification a few drops of acid water and volatile aldehydes came over below 157° C. (corr.). Between 157–172°, 58 per cent. distilled; between 172–245°, 16 per cent. came over; and between 245–266°, 16 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.8606; rotation  $a_D + 13.9^\circ$ .

Second " " " = 0.8647; " " + 2.8°.

Third " " " = 0.9302; " " — 1.3°.

The oil of this species thus differs from that of the "Bloodwood" of the Sydney District, in that the oil of the latter tree is lævo-rotatory. For comparative results between the oils of the three "Bloodwoods" see table under *E. corymbosa*.

Material from this species was also obtained from Tumbulgum, N.S.W., in November, 1897. The oil was practically identical with the above. The specific gravity at 15° C. = 0.8881; and the optical rotation  $a_D + 12.2^\circ$ . The saponification number for the ester was 3.8. The lower boiling terpenes consisted almost entirely of pinene.



## 8. *Eucalyptus eximia*.

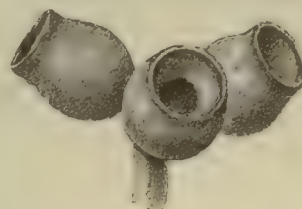
(Schau., in Walp., Rep., ii, 925.)

**White or Yellow Bloodwood.**

**Systematic.**—A good average forest tree, with a yellowish or lightish-coloured, flaky bark. Abnormal leaves large, measuring sometimes up to 12 inches long and 2 inches broad, lanceolate, falcate, on a petiole of about 12 inches long. Normal leaves smaller and more falcate; venation less distinct than in the younger leaves, lateral veins fine, parallel; intramarginal vein close to the edge. Oil glands comparatively numerous. Peduncles chiefly terminal, forming a panicle, broad, flat, over 1 inch long, bearing from six to ten sessile or shortly pedicellate flowers. Calyx under 6 lines long and 3 lines broad, shining; operculum hemispherical, rostrate.

**Fruit.**—Urn-shaped, wrinkled, sessile, contracted at the rim, which is countersunk and sharp-edged; valves depressed; about 7 lines long, 6 lines wide.

*The fruit could easily be mistaken for E. intermedia, so that other material is necessary when determining the species.*



**Habitat.**—Blue Mountains and Gosford, N.S.W.

**REMARKS.**—The field characters of this species, such as the sessile flowers, colour and nature of the bark, timber, and chemical characters, readily differentiate it from the "Sydney Bloodwood" (*E. corymbosa*). It is sometimes known as "White Bloodwood," from the colour of its bark, and pale reddish-coloured timber. It is not widely distributed. In shape of fruit and colour of the timber it resembles *E. intermedia* (R.T.B.).

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Springwood, N.S.W., in August, 1899. The yield of oil was 0.46 per cent.

The crude oil was of a light orange-brown colour, had a turpentine-like odour, and consisted largely of pinene, together with the sesquiterpene alcohol and also geraniol. Cineol was not detected, nor was phellandrene present. The first fraction consisted almost entirely of pinene, while the third fraction was of a greasy appearance, and had a high viscosity. A portion of this fraction apparently consisted of the liquid form of eudesmol as indicated by the high saponification number after acetylation.

The crude oil had specific gravity at 15° C. = 0.8998; rotation  $a_D + 28.8^\circ$ ; refractive index at 20° = 1.4832, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.5.

On rectification a few drops of acid water and a small amount of volatile aldehydes came over below 156° C. (corr.). Between 156–162°, 37 per cent. distilled; between 162–266°, 24 per cent. came over, although only 1 per cent. distilled between 190 and 266°; between 266–280°, 31 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.865; rotation  $a_D + 36.85^\circ$ .

Second " " " " = 0.8737; " " + 30.5°.

Third " " " " = 0.951; " " + 8.7°.

For comparative figures with the oils of the three "Bloodwoods" see table under *E. corymbosa*.

## 9. *Eucalyptus botryoides*.

(Sm., in Trans. Linn. Soc., iii, 286.)

**Mahogany or Bangalay.**

**Systematic.**—In favourable situations a fine upstanding tree, but often gnarled. Leaves lanceolate, broad, and about 6 inches long, shining on the upper side, drying a slate colour; venation well marked, veins transverse, fine and numerous, the intramarginal vein near the edge. Buds compact and sessile, in the early stage the whole covered by a calyptra. Flowers in axillary clusters; calyx angular, cylindrical; operculum conical, short.

**Fruit.**—Mostly sessile, ovoid-oblong, or rounded with a circular groove below the edge; rim countersunk, with or without one or two ridges at the base; valves flat and not exserted, or slightly exserted in some instances; 4 lines long and 3 lines in diameter.



**Habitat.**—Coast district from the North-east corner of Victoria into Queensland.

**REMARKS.**—Although as a general rule the "Mahogany," or "Bangalay," occurs on the banks of creeks, when it is much gnarled, yet it is often to be seen growing on elevated ground and with a straight trunk of large dimensions. The bark is red-coloured, short-fibred, flaky, and brittle. The timber is hard, close-grained, red-coloured, and very durable. The sessile, elongated fruits and buds are characteristic, and almost sufficient alone for the botanical determination of the species. It is fast disappearing in the county of Cumberland, New South Wales, owing to settlement.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Milton, N.S.W., in February, 1900. The yield of oil was 0.11 per cent. The crude oil was dark reddish-brown in colour; the odour rank and far from pleasant. It was very mobile and consisted principally of dextropinene; phellandrene was not present, and but a very small quantity of cineol was detected in the oil distilling between 175–180° C. The higher boiling portion consisted largely of the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.8778, and required 7 volumes 80 per cent. alcohol to form a clear solution. The refractive index at 20° = 1.4730. The saponification number for the esters and free acid was 21.4. The very dark colour of the crude oil indicated an excess of free acid, while the action of the alcoholic potash on the oil suggested that the ester was largely geranyl-acetate, a substance commonly occurring in oils at this end of the genus. The phenols were also pronounced in this oil.

On rectification the usual amount of acid water and volatile aldehydes, for oils of this group, came over below 160° C. (corr.). Between 160–190°, 87 per cent. distilled, and between 190–256°, 5 per cent. came over. The large fraction had sp. gr. at 15° = 0.873; rotation  $\alpha_D + 23.75^\circ$ .

The first fraction was again redistilled, when between 158° and 164° C., 33 per cent. came over; and between 164° and 174°, 35 per cent. distilled. The specific gravity of the first fraction = 0.8696; and the second fraction = 0.8736.



The optical rotation of the first fraction  $\alpha_D + 27.85^\circ$ , and of the second fraction  $\alpha_D + 22.35^\circ$ , so that dextropinene forms the greater portion of the oil of this species. The nitrosochloride was prepared and this melted at the correct temperature for that substance.

Material of this species was also collected at Hurstville, N.S.W., in June, 1898. The oil was almost identical with the above and consisted principally of dextropinene. The specific gravity of the crude oil = 0.8774. The saponification number for the esters and the free acid was 15.2. The crude oil required 9 volumes 80 per cent. alcohol to form a clear solution. The trees at Milton were growing in granite formation, and those at Hurstville in the Hawkesbury sandstone country, so that the constituents of the oil of this species are comparatively constant, irrespective of the geological formation upon which the trees grow.

## 10. *Eucalyptus robusta*.

(Sm., in Bot. Nov. Holl., pp. 39-40, t. 13.)

**Swamp Mahogany.**

**Systematic.**—A fairly large tree, with reddish, brittle bark—between a "Stringybark" and a "Bloodwood" bark. Leaves large and coarse, leathery; lateral veins numerous, straight and parallel; intramarginal vein prominent, close to the edge. Venation thus indicates pinene in the oil. Peduncles axillary, thick, flattened, about 1 inch long. Flowers large. Calyx turbinate and green; operculum cream-coloured, rostrate and slightly larger and broader than the calyx tube.

**Fruit.**—Urceolate; rim bevelled; valves well sunk; only rarely exserted; 9 lines long, including the pedicel.

*A decidedly distinct fruit with its sharp-edged rim and sunken horizontal valves.*



**Habitat.**—Coastal swamps of New South Wales and South Queensland.

**REMARKS.**—A tree easily identified by its comparatively large fruits and by its large, coarse leaves, and habitat, being rarely, if ever, found growing away from low, swampy ground. The timber is red-coloured, hard and durable.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from La Perouse, near Sydney, in August, 1900. The yield of oil was 0.16 per cent. The crude oil was red in colour, and had a turpentine-like odour. It consisted largely of pinene; phellandrene was also detected, but this constituent was only present in a very small amount. Only a trace of cineol could be detected in the second fraction. The oil distilling at near  $270^\circ$  C., consisted mostly of the sesquiterpene.

The crude oil had specific gravity at  $15^\circ$  C. = 0.8777; rotation  $\alpha_D + 4.0^\circ$ ; refractive index at  $20^\circ$  = 1.4744, and required 8 volumes of 80 per cent. alcohol to form a clear solution. The saponification number for the esters and free acid was 9.1.



On rectification the usual amount of acid water and aldehydes came over below  $157^{\circ}$  C. (corr.). Between  $157$ – $162^{\circ}$ , 59 per cent. distilled; between  $162$ – $183^{\circ}$ , 22 per cent. came over; between  $183$ – $255^{\circ}$ , 7 per cent. distilled; and between  $255$ – $279^{\circ}$ , 5 per cent. distilled. These fractions gave the following results:—

|                                   |           |                |            |
|-----------------------------------|-----------|----------------|------------|
| First fraction, sp. gr. at 15° C. | = 0.8658; | rotation $a_D$ | + 4.5°.    |
| Second       "       "       "    | = 0.8673; | "              | + 1.5°.    |
| Third       "       "       "     | = 0.9053; | "              | not taken. |
| Fourth       "       "       "    | = 0.9464; | "              | "          |

The rotation figures indicate that both optically active pinenes were present in the oil of this species, as well as a trace of phellandrene in the freshly-distilled oil.

This sample of oil had been kept in the dark, and in September, 1919, nineteen years afterwards, was again analysed. But little alteration had taken place in the oil during all that time. The specific gravity had increased a little, but no less than 84 per cent. of the oil distilled below  $190^{\circ}$  C. The crude oil and the distillate gave the following results :—

Crude oil, sp. gr. at 15° C. = 0.8925; rotation not taken; refractive index at 20° = 1.4749.

Large fraction    „    „    = 0.8712; rotation  $a_D + 4.8^\circ$ , refractive index at  $20^\circ = 1.4684$ .

The amount of the fraction absorbed by the resorcinol method was equal to 10 per cent. when calculated for the crude oil, the greater portion of which was cineol.

11. *Eucalyptus saligna*.

(Sm., in Trans. Linn. Soc., iii, 285—partly).

### Sydney Blue Gum.

**Systematic.**—A tall tree, growing to its greatest height and perfection in the gullies of the coast. Bark either smooth, bluish-white with a silvery sheen, or rough at the base, similar to that of *E. robusta*. Abnormal leaves alternate, lanceolate. Normal leaves lanceolate, occasionally falcate, drying a bluish-green, pale on the underside; intramarginal vein close to the edge; transverse veins numerous, fine and parallel (slightly oblique). Peduncles axillary, with few, mostly five to seven flowers, either on a slender pedicel or almost sessile; calyx turbinate or conical; operculum hemispherical, shortly acuminate.

**Fruit.**—Mostly more hemispherical than shown in the plate, pedicellate or sessile; rim thin; valves slender, expanded, sharp-pointed, and well exserted; 3 lines long,  $2\frac{1}{2}$  lines in diameter.



The valves inserted just below the rim is a good specific feature by which to determine the fruits.

**Habitat.**—Mostly in, or at, the head of gullies in the Coastal districts of New South Wales.



**A TYPICAL GUM BARK.**

*Eucalyptus saligna*, Sm.

The largest group of all, having a smooth, pinkish, yellowish tint, or whitish bark, powdery on the outside.

The principal constituent in oils of most species having barks of this character is cineol, the terpene being pinene. This is so with those of *E. globulus*, *E. goniocalyx*, &c. On the other hand some "Gums" also yield phellandrene oils in which little cineol occurs as for instance *E. oreades*, *E. coriacea*, &c. A greater variety of oils is thus found in this division than obtains in any of the others.





**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Gosford, N.S.W., in August, 1897. The yield of oil was 0.22 per cent. The crude oil was dark red in colour, caused by the excess of acid attacking the iron of the still, and the action of the phenols on the iron thus removed. The oil was quite limpid, and consisted largely of pinene and cymene, together with the sesquiterpene and esters. Cineol was present only in traces, and phellandrene was absent. The oil had quite an unpleasant odour, probably due to the valeric acid present.

It will be observed that with the variety *pallidivalvis* the oil contains an excess of dextro-rotatory pinene, and consequently the cymene was less in amount, but the high saponification number and high acid value are similar with both oils, while the constitution of the esters is similar also.

The crude oil of *E. saligna* had specific gravity at 15° C. = 0.8731; rotation  $a_D + 1.1^\circ$ ; refractive index at 20° = 1.4789, and was soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 26.2.

On rectification 2 per cent. distilled below 170° C. (corr.). Between 170–180°, 75 per cent. distilled; between 180–240°, 16 per cent. came over; and between 240–255°, 3 per cent. distilled. The latter fractions were quite acid. The third fraction consisted largely of the sesquiterpene. The results with the two first fractions were:—

First fraction, sp. gr. at 15° C. = 0.8635; rotation  $a_D + 2.3^\circ$ .

Second " " " = 0.8679; " " + 0.6°.

The cineol did not exceed 5 per cent. in the first fraction.

In October, 1919, material for distillation was obtained near Sydney. The yield of oil was very small, 0.015 per cent. The crude oil was limpid, and quite similar in composition to that originally obtained in 1897 from material growing at Gosford. The crude oil had specific gravity at 15° C. = 0.8846; rotation not determined; refractive index at 20° = 1.4795, and was soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 35.5; after acetylation the saponification number was 57, equal to 6 per cent. of free alcohol with the  $C_{10}H_{18}O$  molecule.

On rectification, 61.5 per cent. distilled between 167–182° C. It had sp. gr. at 15° = 0.865; rotation  $a_D + 8.3^\circ$ , refractive index at 20° = 1.4767.

This fraction was again distilled, when 50 per cent. came over between 160–165° C., it had rotation  $a_D + 11.0^\circ$ , and refractive index at 20° = 1.4724.

The portion boiling above 165° had rotation  $a_D + 4.8^\circ$ , and refractive index at 20° = 1.4797. It had a strong cymene odour, and as this hydrocarbon has been determined chemically for this group of oils, there appears little doubt but that it was present with the pinene in the oil of this species also.

## 12. *Eucalyptus saligna*, var. *pallidivalvis*.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, 1st Edit. 1902, p. 32.)

### Flooded Gum.

**Systematic.**—The herbarium material of this tree is altogether coarser than that of its allied species *E. saligna*. The leaves are large and broad, and generally dry a fresh, green colour, with a whiteness near the mid-rib, and a pale under surface. Branchlets angled. Peduncles flattened, about 6 lines long, bearing generally over six flowers, pedicel 4 lines long. Calyx 2 lines in diameter, tapering into the pedicel; operculum hemispherical, acuminate.

**Fruit.**—Uniformly pear-shaped, on a short thick pedicel, or sessile, glaucous, sometimes angled; rim thin, and countersunk; valves exserted, mostly obtuse (only exceptionally acute as shown in fig.), white; about 3 lines in diameter.



**Habitat.**—Coastal districts of New South Wales and Queensland.

**REMARKS.**—It has been customary in the past to include botanically under the species (*E. saligna*) two trees known vernacularly as "Blue" and "Flooded" Gum respectively, but in this work the two are separated, the latter being placed as a variety of the former under the varietal name of *pallidivalvis*. The timbers of the two are only distinct as regards texture. The fruits of the variety are fairly constant throughout the area of distribution—the exserted white valves and glaucous calyx being very characteristic. As its physical characters connect it so closely to *E. saligna* we prefer to let it remain as a variety.

Mr. Maiden has raised it to specific rank, under the name of *E. grandis*, *Proc. Roy. Soc., N.S.W.*, vol. lii., p. 501.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Lismore, N.S.W., in July, 1900. The yield of oil was 0.26 per cent. The crude oil was dark red in colour, due to the action of the phenols on the iron derived from the still. It had a strong and somewhat unpleasant odour, evidently due to the presence of aldehydes, acids, and esters. The principal constituent of this oil is dextro-rotatory pinene, proved by its chemical reactions. A small quantity of cineol was detected, but less than 5 per cent. in the second fraction. Esters were present in some quantity, one of which was the valeric acid ester. Phellandrene does not occur in this oil, but free alcohols are present.

The crude oil had specific gravity at 15° C. = 0.8921; rotation not taken, the oil being too dark; refractive index at 20° = 1.4703, and was soluble in 7 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 28.9.

On rectification 2 c.c. distilled below 155° C. (corr.). Between 155–167°, 67 per cent. distilled; between 167–224°, 18 per cent. came over; and between 224–258°, 7 per cent. distilled, which was very acid. These fractions gave the following results:—

|                 |                             |                                    |
|-----------------|-----------------------------|------------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8723; | rotation $\alpha_D + 32.4^\circ$ . |
| Second          | " " " = 0.9001;             | " + 20.5°.                         |
| Third           | " " " = 0.9447;             | " not taken.                       |



Material of this species for distillation was obtained from the following localities in N.S.W.—Lismore, 23rd July, 1900; Tumbulgum, 15th September, 1900; Bulahdelah, 3rd September, 1900; and Barber's Creek, 17th March, 1899. The oils from all this material were practically identical in all their characters, as can be seen from the following table:—

| Species, Locality, and Date of Collection.              | Percentage Yield of Oil. | Specific Gravity at 15° C. Crude Oil. | Optical Rotation $a_D$ First Fraction. | Saponification Number for Esters and Free Acids | Saponification Number for Free Acids alone. |
|---------------------------------------------------------|--------------------------|---------------------------------------|----------------------------------------|-------------------------------------------------|---------------------------------------------|
| <i>Eucalyptus saligna</i> , var. <i>pallidivalvis</i> — |                          |                                       |                                        |                                                 |                                             |
| Lismore, 23rd July, 1900 ... ..                         | 0.255                    | 0.8921                                | + 32.4°                                | 28.9                                            | 9.9                                         |
| Tumbulgum, 15th September, 1900                         | 0.238                    | 0.8924                                | .....                                  | 30.19                                           | 12.6                                        |
| Bulahdelah, 3rd September, 1900 ...                     | 0.162                    | 0.8937                                | + 34.5°                                | 30.6                                            | 11.9                                        |
| Barber's Creek, 17th March, 1899 ...                    | 0.121                    | 0.8860                                | .....                                  | 29.8                                            | 11.4                                        |

The fractions, from those oils redistilled, were identical in each case, so that the results show a remarkable constancy with the several samples. The oil from Bulahdelah, for instance, when compared with that obtained nearly two months earlier from Lismore, is worthy of note. The amount of oil distilling below 167° C., the rotations and specific gravities of the several fractions, the saponification number for the esters, together with the solubility in alcohol, all go to show this close agreement. The nitrosochloride was prepared with the pinene, and this melted at 103–104° C. Although the oil of this form of *E. saligna* contains so much pinene, yet it scarcely falls into the group insoluble in 10 volumes of 80 per cent. alcohol; this peculiarity must, therefore, be due to the esters, and to the free alcohol, because the amount of cineol present is too small to influence the solubility. The crude oils of all our samples formed clear solutions with either 7, 8, or 9 volumes 80 per cent. alcohol.

To determine the approximate amount of free alcohol in the oil of this species a portion of the Lismore oil was acetylated in the usual way, carefully freed from acid and saponified. The saponification number had then increased to 56.04, so that the amount of alcohols present is represented by the saponification number 27.14. The esterised oil had a distinct odour of amyl-acetate. Although amyl-alcohol was present in combination as well as in the free condition, yet, it may be that a portion was also in combination with the valeric acid as an ester. If this is so, then the amyl-alcohol previously determined in the oil of *E. globulus* might have been derived from a similar ester.

The mixed oils of the above tabulated samples were kept in the dark, and in October, 1919, or nineteen years afterwards, the sample was again analysed. But little alteration had taken place during all that time, thus again illustrating the great stability of the pinene Eucalyptus oils. The specific gravity of the crude oil at 15° C. was 0.8950. On rectification 36 per cent. distilled below 160°, 76 per cent. below 180°, and 82 per cent. below 190°.

The portion distilling below 190° C. had specific gravity at 15° = 0.8749; rotation  $a_D$  + 30.8°, and refractive index at 20° = 1.4652.



### 13. *Eucalyptus nova-anglica*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 616, Pl. L.)

**Black Peppermint of New England, N.S.W.**

**Systematic.**—A medium-sized tree, with a dark straight bark, thinner than that of *E. Bridgesiana*, R.T.B., semi-persistent on the trunk, more or less ribbony on the boughs, and deciduous on the ultimate branchlets. Abnormal leaves glaucous, often 3 inches long and  $2\frac{1}{2}$  inches broad; orbicular to cordate, often stem clasping. Normal leaves lanceolate, and, when fully mature, 3 to 4 inches long and  $\frac{1}{2}$  inch wide on the average; veins strongly marked, pinnate, and anastomosing, the intramarginal vein at some distance from the edge. Buds from two or three to six in an umbel; on a flattened stalk of about  $\frac{1}{4}$  inch; the stalklets less flattened and less than half the length of the stalks. The buds glaucous and often pink or purplish, ovoid, the top of the operculum somewhat pointed; the operculum usually about the same size as the calyx tube. The flowers are usually borne in great profusion.

**Fruit.**—Usually glaucous, but sometimes entirely glabrous; hemispherical with a well-defined, more or less domed rim; the three or four valves sometimes well exerted;  $2\frac{1}{2}$  lines long, 2 to 3 lines in diameter.



**Habitat.**—New England district, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were first forwarded to the Museum in Sept., 1899, by Mr. J. F. Campbell from Walcha, N.S.W. The yield of oil was 0.5 per cent. Later, in the years 1907 and 1910, a somewhat extensive investigation was undertaken with the oils of this species growing in the New England District, N.S.W., the results of which were published by us in the Proc. Roy. Soc., N.S.W., Nov., 1911. Material was obtained for distillation from the following localities:—Black Mountain, near Guyra, in August, 1907; Uralla, in July, 1907; Armidale (where it is known as "Red Peppermint"), in June, 1907; and from Tenterfield, in January, 1910. The material from which the original data were obtained, and published in the first edition of this work, was collected in September, 1899, at the time of the year when the lower boiling terpenes might be expected to be present in greatest amount. The crude oils of all the samples were red in colour, due to the action of the phenols on the iron removed from the still; inclined to be viscid, owing to the excess of sesquiterpene, and had a terpene odour not at all distinctive. Light did not pass well with the crude oils until the colour had been removed. The principal constituents in the oil were dextro-rotatory pinene, and the sesquiterpene, of which latter constituent more than half the oil consisted. Cineol was present in minute quantity only, at any time of the year. The peppermint ketone (piperitone) does not appear to occur in the oil of this species, so that the vernacular name "Peppermint" cannot be due to the odour given by the leaves, but probably

to the appearance of the bark, and of the tree generally. The chemistry of the exudation also shows this tree not to belong to the "Peppermint" group.

The following table gives the general results obtained with the crude oils of this species from four localities given above. The yields of oil were from leaves and terminal branchlets collected as for commercial oil distillation.

|                                                   | Black Mt.,<br>6th August,<br>1907. | Uralla,<br>11th July,<br>1907. | Armidale,<br>24th June,<br>1907. | Tenterfield,<br>12th Jan-<br>uary, 1910. |
|---------------------------------------------------|------------------------------------|--------------------------------|----------------------------------|------------------------------------------|
| Yield of oil per cent. ... ..                     | 0.45                               | 0.58                           | 0.44                             | 0.58                                     |
| Specific gravity at 15° C. ... ..                 | 0.9249                             | 0.9245                         | 0.9221                           | 0.9301                                   |
| Optical rotation $a_D$ ... ..                     | +4.3°                              | +4.7°                          | +5.8°                            | +0.9°                                    |
| Refractive index at 20° C. ... ..                 | 1.4848                             | 1.4921                         | 1.4869                           | 1.4932                                   |
| Solubility in 10 volumes 80 per cent. alcohol ... | insoluble                          | ditto                          | ditto                            | ditto                                    |
| Phellandrene ... ..                               | traces                             | ditto                          | ditto                            | none                                     |
| Cineol ... ..                                     | traces                             | ditto                          | presence<br>well<br>marked.      | traces                                   |
| Amount distilling above 245° C. ... ..            | .....                              | 70%                            | 55%                              | 76%                                      |
| Saponification number for ester + free acid ...   | .....                              | 6.4                            | 5.7                              | 6.9                                      |
| Saponification number after acetylation ...       | .....                              | .....                          | .....                            | 63.4                                     |

On rectifying the crude oil of the Tenterfield sample, 1 per cent. distilled below 159° C. (corr.). Between 159–170°, 10 per cent. distilled; between 170–245°, 9 per cent. came over; and between 245–273°, 76 per cent.; over 50 per cent. distilling between 265–273°. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8652; rotation  $a_D$  + 30.3°; refractive index at 20° = 1.4674.

Second " " " = 0.8713; rotation  $a_D$  + 22.4°; refractive index at 20° = 1.4720.

Third " " " = 0.9326; rotation  $a_D$  — 2.1°; refractive index at 20° = 1.4984.

The light passed the third fraction very well when diluted with chloroform. The two first fractions were again distilled, when 9 per cent., calculated on the original oil, came over between 156–157° C. This fraction had specific gravity at 15° = 0.8631; rotation  $a_D$  + 31.6°; refractive index at 20° = 1.4668, and was almost pure pinene. The nitrosochloride melted at 103–4°. The oil of this species is one of the best from which to obtain the sesquiterpene.

The fractions distilling below 170°, as first obtained, had the following specific gravities and rotations:—

Tenterfield, sp. gr. at 15° C. = 0.8652; rotation  $a_D$  + 30.3°.

Armidale " " = 0.8705; " + 24.4°.

Uralla " " = 0.8638; " + 27.7°.

Walcha " " = 0.8670; " + 33.07°.

The crude oil of the original sample from Walcha had specific gravity at 15° C. = 0.907; rotation  $a_D$  + 14.5°; refractive index at 20° = 1.4843, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 5.1.



On rectification 38 per cent. of the oil distilled below  $167^{\circ}$ , and 43 per cent. above  $250^{\circ}$  C. The specific gravity of the first fraction was 0.8670 at  $15^{\circ}$ , and of the other 0.9310. The optical rotation of the first fraction was  $a_D + 33.07^{\circ}$ .

The Walcha sample was stored in the dark, and in December, 1919, was again analysed. Very little alteration had taken place during the twenty years the oil had been kept. On distillation 49 per cent. came over below  $190^{\circ}$  C., which was separated into two fractions,  $155-170^{\circ}$  and  $170-190^{\circ}$ . The crude oil and the two fractions gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9082; rotation  $a_D + 15.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4856.

First fraction „ „ = 0.8684; rotation  $a_D + 34.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4662.

Second „ „ „ = 0.8726; rotation  $a_D + 30.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4680.

The cineol was determined by the resorcinol method in the portion distilling below  $190^{\circ}$  C. When calculated for the crude oil the result was 6 per cent.

**The Sesquiterpene.**—The oil of this Eucalyptus species is one of the best from which to prepare the sesquiterpene in as pure a condition as possible.

300 c.c. of the crude oil were distilled at 10 millimetres pressure. The following fractions were obtained:—

50– $128^{\circ}$  C. gave 56 c.c. = 18.7 per cent.

128– $140^{\circ}$  C. „ 153 c.c. = 51.0 „

Residue „ 91 c.c. = 30.3 „

The second fraction was repeatedly redistilled at the same pressure, finally over sodium, until a fraction representing 20 per cent. of the crude oil was obtained, boiling at  $124-125^{\circ}$  C. This had specific gravity at  $15^{\circ}$  C. = 0.9222; rotation  $a_D + 4.7^{\circ}$ ; and refractive index at  $20^{\circ}$  = 1.4964. These are, therefore, the constants for the sesquiterpene aromadendrene. (See also the article dealing with this substance.)

The sesquiterpene alcohol boiling above  $140^{\circ}$  C. at 10 millimetres was lævo-rotatory. The residue had saponification number after acetylation 115.3, and was lævo-rotatory  $a_D - 15.4^{\circ}$ . The refractive index was 1.5124.



## 14. *Eucalyptus acaciæformis*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 454.)

### Peppermint.

**Systematic.**—A large umbrageous tree attaining several feet in diameter, with a "Peppermint" bark. Abnormal leaves alternate, pale-coloured, lanceolate, usually obtuse, margin crenulate, average size about  $1\frac{3}{4}$  inch by  $\frac{5}{8}$  inch. Normal leaves lanceolate, average size  $2\frac{3}{4}$  inches by  $\frac{1}{2}$  inch; intramarginal vein removed from the edge; lateral veins parallel, at an angle of about  $45^\circ$  from mid-rib. Peduncles short (1 line), angular; bearing six or seven flowers in the head. Calyx tube short; operculum about the same length as the calyx, shortly pointed.

**Fruit.**—Almost sessile, hemispherical; rim narrow, truncate or slightly domed; valves scarcely exerted; 2 lines broad and  $1\frac{1}{2}$  lines long.



*The fruits bear a great resemblance to those of E. Macarthuri, so that the two species cannot be separated on the fruits alone.*

**Habitat.**—New England district, New South Wales.

**REMARKS.**—The authors, when describing this species, speak of the bark as "Peppermint, stringy, rough and furrowed." If this is correct, then on a cortical classification it would be very difficult to place it in any of the groups of this Genus. However, to us it seems to approach more nearly the bark of the "Peppermint" group in texture. It is one of the numerous so-called "Peppermints" of the New England Tableland.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Tenterfield in January, 1910. The material was collected as for commercial distillation, so that the yield is an average one. The crude oil was red in colour, very mobile, and had a rank, turpentine-like odour. It consisted principally of dextro-rotatory pinene, and the sesquiterpene. Phellandrene could not be detected, and cineol was only present in a very small amount. The ester was somewhat large for an oil of this class, and apparently consisted principally of geranyl-acetate. In its general characters the oil of this species has resemblance to that of *E. nova-anglica*, although the larger amount of dextro-rotatory pinene (with a very high rotation), the less yield of oil, higher ester content, lower specific gravity, and the small quantity of the sesquiterpene, all show it to differ from the oil of that species. The following results were obtained with the crude oil:—

|                                             |     |     |     |     |                  |
|---------------------------------------------|-----|-----|-----|-----|------------------|
| Yield of oil per cent.                      | ... | ... | ... | ... | = 0.20.          |
| Specific gravity at $15^\circ$ C.           | ... | ... | ... | ... | = 0.8864.        |
| Rotation $a_D$                              | ... | ... | ... | ... | + $35.7^\circ$ . |
| Refractive index at $20^\circ$ C.           | ... | ... | ... | ... | = 1.4713.        |
| Insoluble in 10 vols. 80 per cent. alcohol. |     |     |     |     |                  |

The saponification number for the esters and free acid was 17.4, while in the cold with two hours' contact it was 16.2.

This result shows the ester to be principally geranyl-acetate, so that, from the cold saponification, the oil contained 5.7 per cent. of that ester.

On rectification less than 1 per cent. came over below  $154^{\circ}$  C. (corr.). Between  $154-157^{\circ}$ , 70 per cent. distilled; between  $157-183^{\circ}$ , 16 per cent. distilled, leaving 13 per cent. of high-boiling constituents. These fractions were:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8644; rotation  $a_D + 40.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4664.

Second „ „ „ = 0.8772; rotation  $a_D + 35.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4690.

The residue, which had specific gravity at  $15^{\circ}$  C. = 0.9833, gave on saponification the number 80.6, or 28.2 per cent. of ester, if calculated as geranyl-acetate. The saponified oil had a distinct odour of geraniol, but sufficient oil was not available to permit of its isolation in the pure condition. The acid of the ester was, however, shown to be acetic, so that all the available evidence, both botanical and chemical, goes to show that the principal ester is geranyl-acetate.

The constitution of the oil also suggests that this species is closely associated with the earlier members of the Genus, similarly with *E. nova-anglica*.

The results obtained with the oil of this species were published by us in the Proc. Roy. Soc., N.S.W., November, 1911.

## 15. *Eucalyptus Rydalensis*, sp. nov.

### Swamp Gum.

**Systematic.**—A medium-sized tree reaching a height of 40–50 feet and a diameter of 18 inches; with a thick and spongy, rough decorticating bark, extending well up the tree. Abnormal leaves shortly petiolate or sessile, ovate to broad-lanceolate, opposite or alternate. Normal leaves lanceolate to broad-lanceolate, more or less shining, acute, usually under 3 inches long; venation fairly distinct in the older leaves, intramarginal vein well removed from the edge, lateral veins distant, roughly parallel, inclined at an angle of  $30^{\circ}-40^{\circ}$  with the mid-rib. Oil glands more prominent in the young leaves. Peduncles short, 1 to 2 lines long, axillary, lateral or in short terminal panicles, each bearing a head of about seven flowers. Buds sessile or almost so, calyx tube turbinate, 1 line in length; operculum hemispherical, half as long as the tube.

**Fruit.**—Broad, turbinate to hemispherical, sessile, more or less shining; rim domed; valves broad and short, exserted; 2 lines long and  $2\frac{1}{2}$  lines in diameter.



*The fruit rather closely resemble those of E. Macarthuri than any other, the slightly rounded rim being perhaps the chief difference.*

**Habitat.**—Rydal, New South Wales.

**REMARKS.**—This is a rare Swamp Eucalyptus as far as is known to us. Mr. Laseron, the Museum Collector, states that he only saw three trees near Rydal, New South Wales. The bark is thick and spongy, but rougher very much higher up than that of *E. viminalis* growing in juxtaposition. It differs, however, very materially from that species in physical characters and chemical constituents, amongst the former may be mentioned the inflorescence, fruits and both forms of leaves. The timber appears to be very inferior. The herbarium material has the facies somewhat of *E. Macarthuri*, but the specific aroma of the latter at once differentiates the two. The buds are not unlike those of *E. maculosa*, but that is the only connection with that species. The fruits which come closest to them in shape are *E. Macarthuri* more particularly, and next, perhaps, *E. angophoroides* and *E. Bridgesiana*, but these are both of a larger size, and trees with a "Box" bark. The abnormal leaves and chemical constituents of the oil are the principal features by which it can be distinguished from its nearest affinity, *E. Macarthuri*.



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were received from Rydal, N.S.W., in October, 1909. The yield of oil was 0.26 per cent.

The crude oil was of a light amber colour, and had a terpene-like odour with little resemblance to ordinary Eucalyptus oil. It consisted principally of dextro-rotatory pinene, together with the sesquiterpene. Phellandrene was not detected, and cineol was only present in very small amount. Esters occur in some quantity, the principal one being geranyl-acetate.

The oil of this species has a strong resemblance to that of *E. acaciiformis*. The crude oil had specific gravity at 15° C. = 0.8854; rotation  $a_D + 24.7^\circ$ ; refractive index at 20° = 1.4717, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 44, while in the cold with two hours' contact it was 36. The secondary odour of the cold saponified oil suggested geraniol.

On rectification 1 per cent. distilled below 157° C. (corr.). Between 157–172°, 62 per cent. distilled; between 172–194°, 10 per cent. came over, and between 194–276°, 20 per cent. distilled. These fractions gave the following results:—

|                              |                                                                                             |
|------------------------------|---------------------------------------------------------------------------------------------|
| First fraction,              | sp. gr. at 15° C. = 0.8606; rotation $a_D + 30.5^\circ$ ; refractive index at 20° = 1.4665. |
| Second     ,,     ,,     ,,  | = 0.8904; rotation $a_D + 4.4^\circ$ ; refractive index at 20° = 1.4747.                    |
| Third       ,,     ,,     ,, | = 0.9388; rotation too dark; refractive index at 20° = 1.4915.                              |

The cineol was determined by the resorcinol method in the portion distilling below 194°. When calculated for the crude oil the result was 8 per cent.

## 16. *Eucalyptus carnea*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1906, p. 303).

**Systematic.**—A tall tree, attaining a height of 100 feet, with a dark-coloured, stringy bark, persistent to the branchlets. Abnormal leaves opposite, sessile, cordate, ovate, acuminate, thin, pale-coloured on the under side, shining, up to 6 inches long and 3 inches broad. Normal leaves lanceolate falcate, up to 9 inches long and from 1 to nearly 3 inches wide, often very oblique at the base especially the larger leaves, coriaceous, pale-coloured on both sides; venation less pronounced than in abnormal leaves, intramarginal vein well removed from the edge, lateral veins distinct, oblique and spreading. Inflorescence usually in terminal panicles, but sometimes in axillary umbels. Calyx tube turbinate, gradually tapering into the flattened pedicel; operculum hemispherical, shortly acuminate.

**Fruit.**—Hemispherical; rim thin; valves sunken; about 3 lines in diameter.

*The fruits morphologically much resemble those of E. acmenioides.*



**Habitat.**—Richmond River, and North Coast district, New South Wales.



**REMARKS.**—This species is placed as a variety of *E. acmenioides* by J. H. Maiden, "Critical Revision," vol. i, p. 263, but as no new data are advanced to justify its reduction to varietal rank, the reasons given when originally described (*loc. cit.*) as a species still hold, and so we can only regard it as a true species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Lismore, N.S.W., in August, 1900. The yield of oil was 0·16 per cent. The crude oil was of a light orange-brown colour, and had a not unpleasant odour. It consisted largely of pinene, which was dextro-rotatory, and phellandrene was quite absent. Cineol was present, but only about 5 to 10 per cent. A very pronounced constituent occurring in this oil was the ester terpinyl-acetate. Only a small quantity of free acetic acid was present in the crude oil, but the ester was partly decomposed on distilling the oil under atmospheric pressure.

The crude oil had specific gravity at 15° C. = 0·8963; rotation  $a_D + 37\cdot2^\circ$ ; refractive index at 20° = 1·4681, and was soluble in 7 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 35·8.

On rectification 2 per cent. came over below 162° C. (corr.). Between 162–172°, 53 per cent. distilled; between 172–193°, 27 per cent. distilled, and between 193–270°, 16 per cent. came over. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0·8715; rotation  $a_D + 33\cdot3^\circ$ .

Second " " " = 0·8954; " " + 35·5°.

Third " " " = 0·9121; " " not taken.

A second consignment of material for distillation was received a month later from Lismore, N.S.W., in order that the comparative constancy of the constituents in the oils might be tested. The two samples were practically identical, as is shown by the following table:—

| Locality and date.                  | Specific gravity at 15° C. | Optical rotation $a_D$ | Saponification number. | Yield of oil per cent. |
|-------------------------------------|----------------------------|------------------------|------------------------|------------------------|
| Lismore, 2nd August, 1900 ... ..    | 0·8963                     | +37·2°                 | 35·8                   | 0·155                  |
| Lismore, 5th September, 1900 ... .. | 0·8901                     | +39·0°                 | 35·29                  | 0·169                  |

In January, 1902, the ester content was again determined in the crude oil of the first sample in order to see what alteration, if any, had taken place during that period. The free acid had increased slightly in amount, otherwise the ester was constant. In the cold with two hours' contact with alcoholic potash, no further alteration was shown, so that it is evident that geranyl-acetate hardly occurs in the oil of this species.

The Lismore, September, sample (*supra*), was stored in the dark, and in December, 1919, was again analysed. Very little alteration had taken place during the nineteen years the oil had been kept. On distillation 78 per cent. came over below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0·8981; rotation  $a_D + 36\cdot8^\circ$ ; refractive index at 20° = 1·4681.

Rectified portion " " = 0·8790; rotation  $a_D + 34\cdot4^\circ$ ; refractive index at 20° = 1·4647.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 11 per cent.

**The acetic Acid ester.**—The amount of ester occurring in the oil of this species is somewhat large, and as the redistillation had demonstrated the presence of acetic acid, which had been derived from the decomposition of an ester, it was decided to proceed further, particularly as the amount of the free acid present in the crude oil was quite small. A quantity of the crude oil was boiled for some time with aqueous potash under a condenser, the aqueous portion separated, evaporated down and filtered. It was then acidified with sulphuric acid, and the volatile acids distilled over until all had been obtained. Qualitative tests showed that acetic acid was present in quantity, but the odour of valeric acid had also been detected, so that it is most probable that both acids were present. (See also the article on the Valeric Acid Ester in Eucalyptus Oils.)

The distillate was exactly neutralised with barium hydrate solution, and the mixed barium salt purified and prepared in the usual manner. The amount of barium was then determined as barium sulphate; 0.4858 gram. of the barium salt on ignition gave 89.3 per cent. of  $\text{BaSO}_4$ , so that the amount of barium acetate in the mixed salt was 90.85 per cent., and the barium valerate 9.15 per cent., assuming that valeric acid was the only other acid present besides acetic. This result suggests that valeric acid may be present as an ester in many crude Eucalyptus oils, and to be connected with the valeraldehyde which occurs so frequently in certain groups. Acetic acid is the free acid occurring in Eucalyptus oils, which is demonstrated in the article dealing with this subject, and it is also present in the oil of *E. Macarthuri*, *E. acervula*, and other numerous species as an ester in combination with geraniol. The alcohol of the ester occurring in the oil of *E. carnea* has now been determined, and that it is not geraniol is shown by the ester not saponifying in the cold when treated with alcoholic potash; it was proved to be dextro-rotatory terpeneol. The portion boiling above  $190^\circ \text{C.}$  was saponified and the separated oil distilled under reduced pressure. A portion was eventually obtained boiling at  $99\text{--}103^\circ \text{C.}$  at 10 millimetres. This had specific gravity 0.93; rotation  $\alpha_D + 60^\circ$ ; refractive index at  $20^\circ = 1.484$ , and gave a fair yield of phenylurethane melting at  $110^\circ \text{C.}$  This is further evidence that terpeneol was formed early in the genus, similarly with geraniol, and probably continues throughout the oils of the entire group.

## 17. *Eucalyptus dextropinea*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1898, p. 417, t. XI.)

### A Stringybark.

**Systematic.**—A tree attaining a height of from 60 to 100 feet or higher, and a diameter up to 5 feet. Bark dark or black on the outside, fibrous, and longer in the fibre than that of *E. laevopinea*. Branches smooth for a considerable distance down, but this feature varies. Leaves almost identical with those of *E. laevopinea* of this work, and resembling also those of *E. obliqua*, L'Her. Abnormal leaves broad, rounded at the base, and very acuminate, opposite or nearly so, on a short petiole, the venation well defined, the intramarginal vein being much removed from the edge. Normal leaves lanceolate, falcate, acuminate, often very oblique, shining on both sides, rather thick, the intramarginal vein



removed from the edge. Umbels axillary with about eight flowers, peduncle flattened. Calyx tube obconical, stalklet 4 to 6 lines long. Buds longer and larger than those of *E. laevopinea*; operculum hemispherical, shortly acuminate. Anthers reniform, connected above by a prominent connective, valves opening by longitudinal slits. Ovary flat-roofed.

**Fruit.**—Hemispherical; rim truncate or rounded, occasionally slightly domed, rarely countersunk like *E. pilularis*, which they closely resemble in shape in some forms; valves slightly exserted; 4 to 6 lines in diameter.



**Habitat.**—Originally described from material obtained from Barber's Creek, mostly in the gullies. It, however, extends south as far as Monga, N.S.W.

**REMARKS.**—The fruits and timber are characteristic of this species, and show it to differ distinctly from *E. Muelleriana*, A. W. Howitt. It is one of the few "Stringybarks" that has a "sapwood"—a good specific difference. From its specific name it may be thought that the optical character is the only feature that differentiates this tree from its congener, *E. laevopinea*, R.T.B., but such is not the case, and its specific rank, as shown by the above description, is founded on well-defined morphological and other features, as well as on its chemical constituents.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, N.S.W., in July, 1898. The yield of oil was 0.85 per cent. The crude oil was red in colour, and had a turpentine-like odour. The presence of volatile aldehydes was not at all pronounced, as it was difficult to even detect them by the odour. Phellandrene was quite absent, and cineol almost entirely so, as it could only be detected in the portion boiling at the most favourable temperature. The oil consisted very largely of a highly dextro-rotatory pinene, and a fair amount of esters. The oil of this species produces a very good turpentine, quite equal to the commercial article.

The crude oil had specific gravity at 15° C. = 0.8778; refractive index at 20° = 1.4684, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 22.9.

On rectification about 1 per cent. distilled below 156° C. (corr.). Between 156–162°, 62 per cent. distilled, and between 162–172°, 25 per cent. came over. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8691; rotation  $\alpha_D + 34.40^\circ$ .

Second " " " = 0.8759; " " + 32.46°.

Material of this species for distillation was also obtained in August, 1898, from Currawang Creek, near Braidwood, N.S.W., many miles from the first locality. The oil differed in no respects from the first sample. The yield of oil was 0.83 per cent. The crude oil had sp. gr. at 15° = 0.8758. On redistillation 63 per cent. came over between 156–162°, and 25 per cent. between 162–172°. The specific gravity of the first fraction was 0.860, and of the second 0.8725. The rotation of the first fraction was  $\alpha_D + 32.83^\circ$ , and of the second  $\alpha_D + 31.7^\circ$ .

The principal ester in the oil of this species is geranyl-acetate, and in a sample of the oil distilled from material collected at Tallong, N.S.W., in October, 1911, half the total esters in the oil was saponified in the cold with two hours' contact.

The oils from Barber's Creek and Currawang Creek were mixed and preserved in the dark, and in October, 1919, twenty-one years afterwards, the sample was analysed. Very little alteration had taken place in the oil during





W. Marshall, del.

EUCALYPTUS DEXTROPINEA. R.T.B.

A STRINGYBARK.

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that period. Between 156–162°, 60 per cent. distilled, and between 162–172° 25 cent. came over. The crude oil and the two fractions gave the following results :—

Crude oil, sp. gr. at 15° C. = 0.8840; rotation  $a_D + 31.0^\circ$ ; refractive index at 20° = 1.4689.

First fraction, „ „ = 0.8670; rotation  $a_D + 31.25^\circ$ ; refractive index at 20° = 1.4651.

Second „ „ „ = 0.8741; rotation  $a_D + 29.80^\circ$ ; refractive index at 20° = 1.4658.

The cineol was determined by the resorcinol method in the oil distilling below 172°. When calculated for the crude oil the result was 6 per cent. The saponification number for the esters and free acid in the crude oil was 17.7. In the cold, with two hours' contact, it was 12; after acetylating, the saponification number had increased to 41.3, and in the cold with two hours' contact it was 22, thus showing the presence of some free geraniol.

For further investigation of the terpene, see the article on the "Pinenes of Eucalyptus Oils." For the corresponding lævo-rotatory pinene see under *E. lævopinea*.

## 18. *Eucalyptus nigra*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 689.)

### Black Stringybark.

**Systematic.**—A tall tree, with a black stringy bark. Abnormal leaves opposite or alternate, thin ovate, acuminate, shortly petiolate; pale on underside, branchlets covered with stellate hairs. Normal leaves lanceolate, scarcely falcate, occasionally oblique, mostly under 4 inches long and under 1 inch wide, of a dull green colour; venation only faintly marked on the upper surface, but very distinctly so on the lower, lateral veins oblique, distinct, intramarginal vein removed from the edge. Peduncles axillary, short, under 4 lines, bearing a cluster of from eight to twelve flowers. Calyx hemispherical, under 2 lines in diameter, on a short pedicel; operculum hemispherical, acuminate, about  $1\frac{1}{2}$  lines long when mature. Ovary flat-topped. Anthers very small, filaments very slender.

**Fruit.**—On thick, angled pedicels, hemispherical to pilular; rim variable, thin, or truncate, and even domed occasionally; valves slightly exserted; about 4 lines in diameter.



*The fruits are very much like those of E. eugenioides.*

**Habitat.**—Richmond River district, Cook's River, Sydney, Blackheath, New South Wales.

**Timber.**—Of a dark brown colour (hence the specific name), comparative only with other "Stringybarks," occasionally affected with borers, and not valued for durability by those interested in the timber trade.



**REMARKS.**—From *E. Wilkinsoniana*, R.T.B. and *E. macrorhyncha*, F.v.M., it differs in fruit, timber, and chemical constituents of the oil. From the "Stringybark," *E. carnea*, R.T.B., it differs in the shape of the abnormal leaves and chemical constituents of the oil, although the immature fruit of these species is somewhat similar. *E. eugenoides*, Sieb., and *E. capitellata*, Sm., often approach each other closely in morphological characters, and there often seems to be a gradation between the two, but, nevertheless, the two species are quite distinct; and so with this species, although there also appears some similarity in its fruits with those of *E. eugenoides*, yet the two species differ in too many characters to be one and the same species. The abnormal leaves are not unlike those of *E. capitellata*, whilst the buds are similar to those of *E. eugenoides*. If it were not for the distinctive character of the timber, oil, &c., it might, perhaps, stand as a variety of *E. eugenoides*, but the former product is of too poor a quality to be associated with so excellent a timber as that yielded by the "White Stringybark," *E. eugenoides*. The oil also differentiates it entirely from that species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Woodburn, N.S.W., in August, 1900. The yield of oil was 0.04 per cent. The crude oil was of an amber colour, and had an odour corresponding to that of the pinene terpene oils. Cineol was detected, but there was not more than 5 to 10 per cent. of that constituent in the crude oil. Lævo-rotatory pinene was present in considerable quantity, but phellandrene was absent. The specific gravity of the crude oil at 15° C. = 0.8744, and the optical rotation  $\alpha_D$  — 34°. The saponification number for the esters and free acid was 7.2. The crude oil did not form a clear solution with 10 volumes 80 per cent. alcohol.

The above sample of oil had been stored in the dark, and in September, 1919, was again analysed. Practically no alteration had taken place in the oil during the nineteen years it had been kept, and it thus follows the rule for the pinene Eucalyptus oils generally—90 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.8770; rotation  $\alpha_D$  — 34.3°; refractive index at 20° = 1.4706.

Rectified portion      „      = 0.8706; rotation  $\alpha_D$  — 38.6°; refractive index at 20° = 1.4669.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 11 per cent.

## 19. *Eucalyptus lævopinea*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1898, p. 414, t. X.)

### Silver-top Stringybark.

**Systematic.**—A very tall tree in favourable situations. Bark fibrous, but brittle, a feature that distinguishes it from that of "Red Stringybark," *E. macrorhyncha*, F.v.M., and "White Stringybark," *E. eugenoides*, Sieb.; ultimate branches smooth. Abnormal leaves alternate or scarcely opposite, broad at the base, but not cordate, acuminate, about 3 inches long; the intramarginal vein removed from the edge, the lateral ones very distinct on the under side, but scarcely showing on the upper surface. Normal leaves varying in size and shape, mostly very oblique, of a very dark green colour, and shining on both sides, lanceolate, falcate, acuminate; the intramarginal vein removed from the

edge, lateral veins fairly distinct. Petiole varying from  $\frac{1}{2}$  to 1 inch long. Umbels axillary, bearing about five to seven flowers; stalks flattened, under 1 inch long, stalklet varying from 3 to 8 lines long; operculum hemispherical, shortly acuminate. Calyx not angular. Stamens all fertile, inflexed in the bud; anthers divergent from the very prominent connective which surmounts them.

**Fruit.**—Hemispherical, pedicellate; rim either slightly inclined outwards, truncate, or quite domed; incised ring just below the lower edge; valves exserted; varying in diameter from 3 to 6 lines.



*The domed fruit form resembles somewhat that of E. macrorhyncha.*

**Habitat.**—On basaltic outcrops in the Coastal Mountain Ranges; Nulla Mountain, Rylstone, Never Never Mountain, Gulf Road, Black Mountain, Tenterfield, Uralla, Armidale, New South Wales; and Lilydale, Yarra Junction, Victoria.

**REMARKS.**—This tree has always been regarded by local residents of the districts where it occurs as quite distinct from any of the other "Stringybark" trees in the Rylstone district, owing to its peculiar bark and tough wood, and the glinting of the leaves in the sun, which makes them appear glaucous, and hence its vernacular name of "Silver-top Stringybark." When seen growing in its native habitat, it somewhat resembles *E. macrorhyncha*, F.v.M., and the mature fruits with the domed rim and well-exserted valves might perhaps lead one to diagnose it as that species, from which it differs principally in its hard, durable timber, and nature of the bark, as well as in its operculum, calyx tube, oblique leaves, and in the chemical character of its oil. Except for the domed fruits, there is little to connect it botanically with *E. macrorhyncha*, F.v.M., a species the leaves of which yield (1) the dye myrticolorin, (2) an oil, rich in the stearoptene eudesmol, and also cineol. These bodies are absent from the leaves of this particular Eucalypt, and the oil is almost entirely composed of lævo-rotatory pinene. It differs from *E. dextropinea*, R.T.B., in the shape of its fruits, the superior quality of its timber, and the presence of a lævo-rotatory pinene in its essential oil. From an economic point of view the confounding of this tree with *E. macrorhyncha*, F.v.M., would be fatal to the establishment of an industry for the particular products for which each species is suitable.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nulla Mountain, Rylstone, N.S.W., in August, 1898. The yield of oil was 0.66 per cent. The crude oil was red in colour and had a turpentine-like odour. Phellandrene was absent, and cineol only present in small amount, about 8 or 10 per cent. The oil consisted very largely of pinene, which was highly lævo-rotatory, and it contained a smaller amount of esters than were present in the oil of *E. dextropinea*.

The crude oil had specific gravity at 15° C. = 0.8755; rotation  $a_D$  — 37.8°; refractive index at 20° = 1.4704, and was scarcely soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 7.0.

On rectification 1 per cent. distilled below 157° C. (corr.). Between 157–164°, 60 per cent. distilled; and between 164–172°, 28 per cent. came over. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8699; rotation  $a_D$  — 40.66°.

Second " " " = 0.8748; " — 38.75°.

The cineol was only present in small amount, and could not be determined quantitatively at that time.

For the further determination of the terpene, see the article in this work on "The Pinenes of Eucalyptus Oils."



This sample of oil had been preserved in the dark, and in October, 1919, twenty-one years afterwards, was again analysed. It had become a little heavier and the optical activity had lessened a little also, otherwise the alteration which had taken place in the oil during all that period was small. Between 157–164°, 53 per cent. distilled; and between 164–178°, 23 per cent. came over. The crude oil and the fractions gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9006; rotation  $a_D$  — 35.8°; refractive index at 20° = 1.4709.

First fraction „ „ = 0.8742; rotation  $a_D$  — 38.1°; refractive index at 20° = 1.4646.

Second „ „ „ = 0.8832; rotation  $a_D$  — 35.6°; refractive index at 20° = 1.4660.

The cineol was determined by the resorcinol method in the oil boiling below 178°. When calculated for the crude oil the result was 13 per cent. (See also results with the oil of *E. dextropinea*.)

In the year 1907 the opportunity came for determining the oil of this species from Northern New South Wales. The results of that investigation were published by us in the Proc. Roy. Soc., N.S.W., Nov., 1911.

Leaves and terminal branchlets for distillation were obtained from Armidale in July, 1907, and from Uralla in the same month. The crude oil in both instances was red in colour; this being due to the action of the phenols on the iron derived from the still, was easily removed by aqueous alkali. The oil thus treated, after well washing and drying, was of a light lemon colour, but when rectified was colourless. The crude oil had a turpentine-like odour, this being more pronounced in the rectified oil. Phellandrene does not occur in the oil of this species, so that in this respect it differs from the oil of *E. macrorhyncha*, and the stearoptene eudesmol, although such a pronounced constituent in the oil of *E. macrorhyncha*, was not found in that of *E. laevopinea*. Cineol was present to a small extent. The following table gives the general results obtained with the crude oils, those previously recorded for this species from Rylstone being given for comparison:—

|                                                             | Rylstone,<br>1st August,<br>1898. | Armidale,<br>1st July,<br>1907. | Uralla,<br>13th July,<br>1907. |
|-------------------------------------------------------------|-----------------------------------|---------------------------------|--------------------------------|
| Yield of oil, per cent. ... ..                              | = 0.66                            | = 0.59                          | = 0.57                         |
| Specific gravity at 15° C. ... ..                           | = 0.8755                          | = 0.8875                        | = 0.8871                       |
| Rotation $a_D$ ... ..                                       | — 37.8°                           | — 30.7°                         | — 33.3°                        |
| Rotation of portion distilling below 164° C. ... ..         | — 40.65°                          | — 36.4°                         | — 38.6°                        |
| Refractive index at 20° C. ... ..                           | 1.4704                            | 1.4686                          | 1.4692                         |
| Solubility in 80 per cent. alcohol, scarcely soluble in ... | 10 volumes                        | ditto                           | ditto                          |
| Cineol ... ..                                               | 5 to 10 %                         | ditto                           | ditto                          |
| Amount distilling below ... ..                              | 164° C. = 60%                     | 163° C. = 62%                   | 164° C. = 63%                  |
| Saponification number for esters and free acid ... ..       | 7                                 | 11.06                           | 10.27                          |

The trees of this species growing in the New England District of New South Wales, thus gave an oil in agreement with that from Rylstone, although the two localities are very far apart.





*EUCALYPTUS LAEVOPINEA*, R.T.B.  
SILVER TOP STRINGYBARK.



200 c.c. of the Armidale sample were rectified, using rod and disc still head. The oil commenced to distil at  $155^{\circ}\text{C}$ . (corr.). Between  $155$ – $158^{\circ}$ , 100 c.c. came over; and between  $158$ – $170^{\circ}$ , 50 c.c. more, or 75 per cent. below  $170^{\circ}\text{C}$ . These two fractions were again distilled, when 100 c.c. came over below  $156^{\circ}$ , and 20 c.c. more between that temperature and  $159^{\circ}\text{C}$ .

The oil distilling below  $156.5^{\circ}$  had specific gravity at  $15^{\circ}\text{C}$ . = 0.8682; rotation  $a_D - 38.9^{\circ}$ ; refractive index at  $20^{\circ}\text{C}$ . = 1.4651. The second fraction had almost the same specific gravity and refractive index, but the rotation was a little less,  $a_D - 36.0^{\circ}$ . The terpene was definitely shown to be lævo-rotatory pinene.

The odour of the distillate resembled that of commercial turpentine. The oil was water-white, and had properties closely approaching those for pure pinene, although a little cineol still remained. (For the corresponding dextro-rotatory pinene see under *E. dextropinea*.)

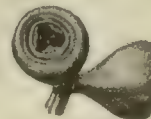
## 20. *Eucalyptus phlebophylla*.

(F.v.M. & MIQ., Ned. Kr. Arch., IV, 140.)

**Cabbage or Weeping Gum.**

**Systematic.**—A tree reaching 40 or 50 feet in height, with spreading limbs, weeping branches, and branchlets that hang down 10 or 12 feet, the latter often glaucous or reddish. Abnormal leaves alternate, petiolate, ovate to ovate lanceolate, up to 8 inches long and 3 inches broad; venation prominent, almost parallel to the mid-rib. Normal leaves lanceolate to linear lanceolate, thick, shining, acuminate, often falcate, about 5 inches long; venation almost parallel to the mid-rib. Oil glands numerous. Umbels of about six to twelve flowers, borne on axillary or lateral peduncles about 4 lines long. Buds glaucous, somewhat clavate, about 4 lines long. Calyx tube tapering to base; operculum hemispherical, usually shortly pointed.

**Fruits.**—Broadly turbinate, truncate; rim red, broad, horizontal or slightly domed; valves not exserted; 4 lines long and 5 lines broad.



*The main features which distinguish these fruits from E. coriacea—its nearest affinity, are their larger size and more woody nature.*

**Habitat.**—New South Wales, Victoria, Tasmania.

**REMARKS.**—This tree was described by Miquel in 1856 (Ned. Kruidk. Arch., iv, 140), on behalf of Baron Mueller, from the Tasmanian specimens of Stuart. Bentham, in his "Flora Australiensis" (vol. iii, p. 210), synonymises it with *E. coriacea*, A. Cunningham, under which species Mueller also places it in his "Eucalyptographia" (1879). Possibly Mueller had not seen specimens of Cunningham's *E. coriacea* when he described this species in conjunction with Miquel, and so probably was not acquainted with the New South Wales and mainland trees now going under the name of *E. coriacea*, that is, Cunningham's and Sieber's tree—*E. pauciflora* of the latter—and so considered he had a new species at the time, for we know that later he placed it under *E. coriacea*. Since that date it has been customary to regard the Tasmanian and mainland trees as one species, but the investigations taken in connection with our research work show that such is not the case, and that the two are separate species, and so Mueller was correct after all. The original name of *E. phlebophylla* is thus restored. Mueller, however, concurs in Bentham's synonym (supra) in his "Eucalyptographia" and places the Tasmanian and mainland trees under *E. coriacea* in that book. This lumping of species, even his own, was characteristic of the Baron in his later work. Maiden, in his "Critical Revision of Eucalypts," agrees with Bentham's and Mueller's later classification. The differences between this species and *E. coriacea*, with which it has been associated by various botanists, are fully detailed in our publication on the Tasmanian Eucalypts, Roy. Soc. Tas., 1912, p. 27–9. Maiden disagrees with our classification, Roy. Soc. Tas., 1914, p. 27, but the botanical and chemical results favour separation.



**ESSENTIAL OIL.**—Material for distillation was collected at Tunbridge, Tasmania, in June, 1912. The yield of oil was 1 per cent. The crude oil was light olive-brown in colour, had a terpene-like odour, and consisted principally of lævo-rotatory pinene; cineol and eudesmol were both present, the latter in quantity, as it crystallised from the higher boiling fraction. The so-called "Cabbage or Weeping Gum" is common both in Australia and Tasmania. Oil was first distilled from this Eucalypt by Mr. Marsden, at Muloon, near Boro, N.S.W., in February, 1908, and it was brought under our notice by Mr. Farrell, of the Australian Eucalyptus Oil Company, on account of its strong odour of turpentine, and the low temperature at which it boiled. When submitted to us it was a colourless oil, as it had been rectified, and was found to contain a small amount of cineol, and to consist almost entirely of lævo-rotatory pinene, with some eudesmol. In September, 1910, Mr. Farrell noted this species growing at Monga, N.S.W., and he had the leaves distilled, and submitted the crude oil to us for investigation. The oil was light olive-brown in colour, had an odour of turpentine, was very mobile, and besides consisting largely of lævo-rotatory pinene, contained some cineol and eudesmol. Even more pinene was present than in the Tasmanian oil, but this may be due to the difference in the time of the year, or partly to the mode of distillation, as the Monga oil had been distilled from an ordinary pot-tank still, which naturally does not bring over the high boiling constituents so completely as when the steam is supplied from a boiler. The Monga oil had specific gravity at 15° C. = 0.8766; rotation  $a_D$  — 32.5°; refractive index at 20° = 1.4679; and contained 11 per cent. of cineol by the resorcinol method. Over 80 per cent. of the total oil distilled below 170° C. (corr.).

The oil from the Tasmanian trees (our own distilling) had specific gravity at 15° C. = 0.8925; rotation  $a_D$  — 22.4°; refractive index at 20° = 1.4752, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 3.2.

On rectification, a very small amount of acid water and volatile aldehydes came over below 157° C. (corr.). Between 157–172° 66 per cent. distilled; and between 172–192°, 9 per cent.; the temperature then quickly rose to 265°, only a few drops distilling; and between 265–282°, 20 per cent. distilled, which largely consisted of crystallised eudesmol and the sesquiterpene. These fractions gave the following results:—

|                             |                                                                                       |
|-----------------------------|---------------------------------------------------------------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8710; rotation $a_D$ — 35.2°; refractive index at 20° = 1.4658. |
| Second     ,,     ,,     ,, | = 0.8809; rotation $a_D$ — 21.2°; refractive index at 20° = 1.4671.                   |
| Third     ,,     ,,     ,,  | = 0.9418; rotation, not taken; refractive index at 20° = 1.5010.                      |

The cineol was determined by the resorcinol method in the portion distilling below 192° C., and when calculated for the original oil represented 9 per cent.; the absorption, however, might include some eudesmol brought over in the distillate. The pinene was determined in the first fraction, and an amount equal to 30 per cent. of the total oil came over between 156–157° C. It had an odour resembling ordinary turpentine. The specific gravity at 15° C. = 0.8661; rotation  $a_D$  — 38.1°; and refractive index at 20° = 1.4650. The nitrosochloride was easily prepared with it, and this melted at the correct temperature. It may be assumed, therefore, that 50 or 60 per cent. of the oil of this Eucalyptus consists of lævo-rotatory pinene, and this is confirmed by both the Monga and Muloon samples. Whilst the chief constituent of the oil of this species is pinene, that of the oil of *E. coriacea* is phellandrene. Other differences are also shown between the oils of these two species.

In August, 1919, Mr. A. R. Penfold distilled oil from the leaves of this species growing in the Braidwood District, N.S.W. The oil agreed in constituents and characters with those recorded above, and consisted practically of lævo-rotatory pinene and crystallised eudesmol. Phellandrene was absent and cineol only present in traces. The yield of oil was 1.45 per cent. The crude oil had specific gravity at 15° C. = 0.9132; rotation  $\alpha_D - 19.1^\circ$ , refractive index at 20° = 1.4836°. The saponification number for the esters and free acid was 4. A portion of the oil was acetylated in the usual way. The saponification number was then 101.8, while in the cold with two hours' contact it was 20.8. The high saponification number was largely due to the eudesmol.

On rectification the oil commenced to distil at 154° C. Between 154–169°, 35 per cent. distilled; between 169 and 190°, 17 per cent. came over; between 190–268°, 7 per cent. distilled; and between 268–290°, 38 per cent. distilled. 100 c.c. of the oil was then steam-distilled, and 60 per cent. collected. The remainder in the flask soon crystallised into a solid mass, and pure eudesmol was prepared from this.

On rectifying the first distillate no less than 50 of the 60 per cent. distilled between 155–157°, principally at 156° C. This had specific gravity at 15° = 0.8625; at 20° = 0.8588. Specific rotation  $[a]_D - 50.18^\circ$ , and is thus one of the highest lævo-rotatory pinenes known. The pure eudesmol had specific rotation  $[a]_D + 27.07^\circ$ , and melted at 79–80° C.

## 21. *Eucalyptus alpina*.

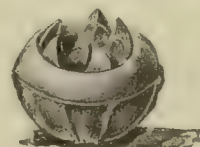
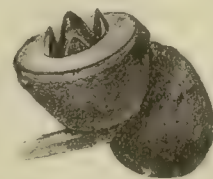
(Lindl. Mitch., Three Exp., II, 175, 1838.)

**Systematic.**—A stunted tree or shrub; branchlets stout, rugose. Normal leaves on thick petiole, from broad oblong lanceolate to roundish, thick, coriaceous; intramarginal vein well removed from the edge; venation oblique. Oil glands not prominent. Flowers sessile in the axils, from one to five together. Buds about 5 lines long, warty-rough; operculum irregularly semi-ovate, or semi-globular. Calyx tube nearly hemispherical, as long or slightly longer than the lid.

**Fruits.**—Broad, almost hemispherical, comparatively large when full grown (as shown in accompanying plate), sometimes ribbed; rim broad, convex, highly domed, slightly concave or truncate; valves well exerted, prominent; from 5 to 9 lines in diameter.

*Perhaps the nearest Eucalyptus fruits to these in shape are those of E. globulus and E. cosmophylla.*

**Habitat.**—The Grampians, Victoria.



**REMARKS.**—This Alpine Eucalyptus does not present much difficulty in systematic placing. The leaves are thick and leathery, and the buds roughly warted, like those of *E. globulus*. Maiden is inclined to regard it as a variety of *E. capitellata*, "Critical Revision" Vol. I, p. 260. Morphologically and chemically, however, it is not at all closely connected with either of those species.



**ESSENTIAL OIL.**—We are indebted to Mr. C. W. D'Alton, of Hall's Gap, Grampians, Vic., through Mr. Audas, F.L.S., for the material for chemical investigation. The leaves, with terminal branchlets, collected from trees 12 to 30 feet high, showed the presence of a considerable number of oil glands, but these must have been largely empty, judging from the yield of oil, as this was only 0.36 per cent.

The crude oil was thin and mobile, had a terpene-like odour, suggesting turpentine. Phellandrene was not detected, and cineol only present in small amount. The solid paraffin peculiar to some Eucalyptus oils (Proc. Roy. Soc., N.S.W., July, 1913) was also detected.

The analysis shows this oil to consist largely of pinene, the *lævo*-rotatory form slightly predominating. Although belonging to the group of Eucalypts producing a cineol-pinene oil, yet the species has no commercial value as an oil-producing plant, the yield being much too small, while the oil itself is deficient in oxygen-bearing constituents.

The crude oil had specific gravity at 15° C. = 0.8973; rotation  $a_D$  — 2.8°; refractive index at 20° = 1.4756, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.6.

On rectification the usual amount of acid water and volatile aldehydes came over below 155° C. (corr.). Between 155–163°, 66 per cent. distilled between 163–215°, 16 per cent. came over (14 per cent. below 180°); between 215–285° only 1 per cent. distilled, leaving 16 per cent. in the still boiling above the latter temperature. Besides some paraffin this residue probably consisted largely of polyterpenes. The first two fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8669; rotation  $a_D$  — 3.9°; refractive index at 20° = 1.4655.

Second       ,,       ,,       ,,       = 0.8783; rotation  $a_D$  — 3.2°; refractive index at 20° = 1.4657.

The first fraction had an odour resembling turpentine, and gave the characteristic nitrosochloride for pinene, thus showing this fraction to consist largely of that terpene. The cineol was determined by the resorcinol method in the portion distilling below 190°. When calculated for the crude oil, the result was 10 per cent.

The results of this investigation were published by us in Jour. Roy. Soc., Victoria, 27 (N.S.), pt. 11, 1914.



## GROUP II.

In this Group are placed the following EUCALYPTS yielding an oil consisting principally of pinene and cineol; the latter constituent not exceeding 40 per cent., determined by the phosphoric acid method at time of distillation. Phellandrene and aromadendral\* are absent.

- |     |                   |                                       |
|-----|-------------------|---------------------------------------|
| 22. | <i>Eucalyptus</i> | <i>Wilkinsoniana.</i>                 |
| 23. | <i>E.</i>         | <i>eugeniioides.</i>                  |
| 24. | <i>E.</i>         | <i>umbra.</i>                         |
| 25. | <i>E.</i>         | <i>santalifolia.</i>                  |
| 26. | <i>E.</i>         | <i>Blaxlandi.</i>                     |
| 27. | <i>E.</i>         | <i>microcorys.</i>                    |
| 28. | <i>E.</i>         | <i>hemilampra.</i>                    |
| 29. | <i>E.</i>         | <i>corynocalyx.</i>                   |
| 30. | <i>E.</i>         | <i>fasciculosa.</i>                   |
| 31. | <i>E.</i>         | <i>megacarpa.</i>                     |
| 32. | <i>E.</i>         | <i>redunca.</i>                       |
| 33. | <i>E.</i>         | <i>Lehmanni.</i>                      |
| 34. | <i>E.</i>         | <i>leucoxylon.</i>                    |
| 35. | <i>E.</i>         | <i>rudis.</i>                         |
| 36. | <i>E.</i>         | <i>maculata.</i>                      |
| 37. | <i>E.</i>         | <i>intertexta.</i>                    |
| 38. | <i>E.</i>         | <i>lactea.</i>                        |
| 39. | <i>E.</i>         | <i>paludosa.</i>                      |
| 40. | <i>E.</i>         | <i>Baeuerleni.</i>                    |
| 41. | <i>E.</i>         | <i>viminalis</i> , var. ( <i>a</i> ). |
| 42. | <i>E.</i>         | <i>paniculata.</i>                    |
| 43. | <i>E.</i>         | <i>cornuta.</i>                       |
| 44. | <i>E.</i>         | <i>quadrangulata.</i>                 |
| 45. | <i>E.</i>         | <i>conica.</i>                        |
| 46. | <i>E.</i>         | <i>Bosistoana.</i>                    |

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\*The name Aromadendral is used throughout this work in a general sense to denote the presence of one or more members of this group of characteristic aldehydes, which includes cuminaldehyde and cryptal. See the article in this work on these aldehydes.\*

## 22. *Eucalyptus Wilkinsoniana*.

(R.T.B., Proc. Linn. Soc., N.S.W., p. 678, t. XLVI, fig. 2.)

**Small-leaved Stringybark.**

**Systematic.**—A medium-sized tree with a thin, compressed, not furrowed, stringy-bark. Leaves lanceolate, falcate, generally under 3 inches long and under 6 lines wide, oblique, thin; venation oblique, parallel, distant, intra-marginal vein removed from the edge. Flowers on axillary peduncles of about 6 lines long. Calyx small, 1 line long, 2 lines in diameter, pedicel about 1 line long; operculum small, hemispherical, acuminate.

**Fruit.**—Hemispherical, sessile or shortly pedicellate; rim thick, red; valves slightly exerted, acute; 2 lines long and 2 to 3 lines in diameter.



*The shape and red rim bring it closely to those of E. hæmastoma, var. micrantha.*

**Habitat.**—Coast Ranges and districts of New South Wales.

**REMARKS.**—The timber is pale-coloured, very hard, close-grained, heavy. In transverse and compression tests, it ranks higher than that of any of the other "Stringybarks" here enumerated. It is an excellent timber, and is strongly recommended for forest conservation. This is the "Stringybark" variety of *E. hæmastoma*, Sm., mentioned by Baron von Mueller in his "Eucalyptographia" under that species. It differs, however, from *E. hæmastoma*, in the nature of the timber, texture, venation of the leaves, bark, and chemical constituents of the oil, and it is on these differences that it is now raised to specific rank. The red rim of the fruit has evidently been the cause of the misplacing of this species, but it is now well known that this is a character common to a number of Eucalypts. It was placed later as a variety of *E. lævopinea*, R.T.B., on chemical evidence alone, but when the tree was better known its characters were such as to warrant specific rank. The red-coloured rim is quite absent from *E. lævopinea*, R.T.B. In fact, the fruits of the two species are so very different that the trees could not be synonymised with any degree of correctness in specific naming. Their bark, leaves, venation, and timber are also different. *E. lævopinea*, R.T.B., has a hard, compact bark right out to the branchlets, whilst this tree has a light-coloured, loose, stringy bark, not extending out to the limbs.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, N.S.W., in January, 1899. The yield of oil was 0.98 per cent. The crude oil was but slightly coloured, and had an odour resembling that of ordinary turpentine. It consisted principally of pinene, which was lævo-rotatory. Cineol was detected, but phellandrene was absent.

The crude oil had specific gravity at 15° C. = 0.8944; rotation  $a_D$  — 21.4°, refractive index at 20° = 1.4717, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 5.

On rectification, 2 per cent. distilled below 157° C. (corr.). Between 157–170°, 84 per cent. distilled, and between 170–224°, 11 per cent. distilled. The lower boiling fraction consisted very largely of lævo-rotatory pinene.

The first fraction had specific gravity at 15° = 0.8847, and rotation  $a_D$  — 23.8°. The specific gravity of the second fraction at 15° was 0.921. The results show this oil to agree closely with that distilled from *E. lævopinea*. Cineol indicated about 15–20 per cent.

The above sample was stored in the dark, and in December, 1919, was again analysed. Very little alteration had taken place during the twenty years the oil had been kept. On distillation 85 per cent. came over below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9032; rotation  $a_D$  — 21.8°; refractive index at 20° = 1.4719.

Rectified portion „ „ = 0.8873; rotation  $a_D$  — 22.15°; refractive index at 20° = 1.4638.

The cineol was determined by the resorcinol method in the rectified portion. When calculated for the crude oil the result was 29 per cent. By the rapid phosphoric acid method it was 21 per cent. when calculated for the crude oil.

## 23. *Eucalyptus eugenioides*.

(Sieb., in Pl. Exs., p. 479, and Fl. Mixt., p. 603; DC. Prod., iii, 218.)

### White Stringybark.

**Systematic.**—A tall tree. Bark thick, stringy, of a clean, reddish colour, or hoary on the external fibres. Abnormal leaves ovate, lanceolate, with crenulate edges, scabrous, oblique, acuminate, on a petiole of about  $\frac{1}{4}$  inch long; venation fine, lateral veins oblique, parallel, intramarginal vein removed from the edge. Leaves of mature trees falcate, lanceolate, oblique, medium size, often shining; venation similar to that of the early leaves. Peduncles axillary, very numerous at the base of the branchlets, compressed, with many flowers. Calyx 2 to 3 lines long, tapering into a short pedicel; operculum conical, obtuse, about as long as the calyx.

**Fruit.**—Hemispherical, very shortly pedicellate or sessile; rim wide, red coloured; valves not exerted, or only slightly so; about  $\frac{1}{4}$  inch in diameter.



*In shape nearest to E. capitellata, but smaller, and only rarely compressed, as obtains in that species. They are also not unlike E. Wilkinsoniana. Rim often a little wider than shown in the figure.*

**Habitat.**—Probably the most widely distributed species on the coast and tableland of New South Wales, Victoria, and Queensland.

**REMARKS.**—A tree very rarely known by any other vernacular name than that of "White Stringybark." The buds and fruits are smaller than those of the other "Stringybarks," and these, together with the timber, form the chief botanical distinctions. Timber-getters and bushmen distinguish it from its congeners by its timber, which has a great reputation for durability in the ground, and being fissile is in much request for posts and rails.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Canterbury, near Sydney, in June, 1898. The yield of oil was 0.7 per cent. The crude oil was almost colourless, of a light-lemon colour, and



had rather a pleasant odour, somewhat aromatic. Pinene was the principal low-boiling terpene, and phellandrene was absent. Cineol was present in fair amount at time of distillation. The sesquiterpene was a pronounced constituent.

The crude oil had specific gravity at  $15^{\circ} = 0.9132$ ; rotation  $a_D + 3.41^{\circ}$ , refractive index at  $20^{\circ} = 1.4694$ , and was soluble in 6 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 6.9.

On rectification, 2 per cent. distilled below  $172^{\circ}$  C. (corr.). Between  $172-174^{\circ}$ , 21 per cent. distilled; and between  $174-193$ , 59 per cent. distilled; the remainder consisted largely of the sesquiterpene. The fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. =  $0.9042$ ; rotation  $a_D + 4.16^{\circ}$ .

Second „ „ „ =  $0.9092$ ; „ „ +  $2.63^{\circ}$ .

The cineol, determined by the phosphoric acid method in the crude oil, was 31 per cent. (O.M.).\*

Material of this species was also obtained at Canterbury, N.S.W., in July, 1897. The colour, odour, constituents, and physical properties of the crude oil were practically identical with those of the previous sample. The yield of oil was 0.8 per cent. The crude oil had specific gravity at  $15^{\circ}$  C. =  $0.9122$ ; rotation  $a_D + 4.8^{\circ}$ , and was soluble in 7 volumes 70 per cent. alcohol.

The cineol, determined by the phosphoric acid method, was 28 per cent. (O.M.). The solubility in alcohol of the crude oil of this species increased as it became richer in cineol, and at the end of three and a half years it was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol.

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. The increase in cineol was quite pronounced. This was noticed before the first edition of this work was published, and a note was added at the time recording this peculiarity.

The crude oil and the rectified portion gave the following results. 86 per cent. distilled below  $190^{\circ}$  C. :—

Crude oil, sp. gr. at  $15^{\circ}$  C. =  $0.9393$ ; rotation  $a_D + 3.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4707$ .

Fraction, „ „ =  $0.9158$ ; rotation  $a_D + 2.5^{\circ}$ ; refractive index at  $20^{\circ} = 1.4636$ .

The cineol was determined by the resorcinol method in the fractionated oil, and calculated for the crude oil; the result was 72 per cent. By the rapid phosphoric acid method it was 58 per cent., when calculated for the crude oil. The saponification number for the esters in the rectified portion was 11.7, and after acetylation 24.7. It is thus evident that bodies other than cineol, alcohols and esters, were absorbed by resorcinol.

\* (O.M.) denotes original determination by phosphoric acid for the first edition of this work. See also the article on *cineol* (or *eucalyptol*).



*EUCALYPTUS EUGENIODES*, SIEB.

WHITE STRINGYBARK.

70. 1940  
1940-1941





A TYPICAL STRINGY BARK.

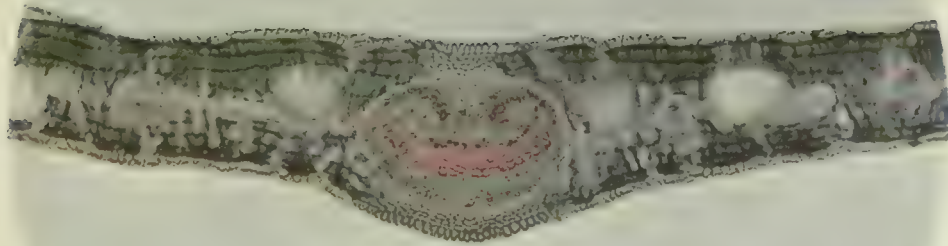
*Eucalyptus eugenioides*, Sieb.

These barks are characterised by the long fibres which intertwine and cross lattice-like, forming ridges and depressions, and are reddish-brown or grey in colour.

The oils of Eucalypts with barks of this character usually consist of pinene with cineol, although occasionally phellandrene occurs in those of some species. The "Stringybarks" seem to be the connecting group between the "Boxes" and the "Peppermints."

70. 1944  
1944-1945

PLATE XXI.



*Eucalyptus eugenioides*

The species of the Stringybark Group are all fair yielders of oil, and in this cross-section, taken near the mid-rib, three medium-sized oil glands are seen. Those nearest the mid-rib are not cut through the centre but the one to the right gives about the average size for this class of *Eucalyptus*. The mesophyll is of small dimensions, the leaf structure being composed mostly of palisade tissue, the cells towards the upper side being the larger. x 55.

**EUCALYPTUS EUGENIODES, SIEB.**





## 24. *Eucalyptus umbra*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1901, p. 687, t. XLIV.)

**Stringybark, White Mahogany.**

**Systematic.**—A tall tree, attaining sometimes a height of 100 feet, with a dark-coloured stringy bark. Abnormal leaves opposite, sessile, cordate, ovate, acuminate, thin, pale-coloured on the underside; venation more pronounced on the underside, upper surface shining; over 3 inches broad, and under 6 inches long. Normal leaves lanceolate, falcate, large, up to 9 inches long and  $1\frac{1}{2}$  inch broad, pale-coloured on both sides, coriaceous; venation distinct, lateral veins spreading, oblique; intramarginal vein removed from the edge. Flowers on short axillary peduncles, six to nine in the umbel. Calyx 1 line long, on a pedicel about 2 lines long; operculum hemispherical, shortly acuminate.

**Fruit.**—In the *early stage*, pilular and under 3 lines in diameter, the rim and valves sunk, like *E. acmenioides* and *E. carnea*, but in the mature stage hemispherical, or inclined to be pear-shaped, with a diameter of 5 lines, and a very thick red, truncate or slightly domed rim, when the fruits much resemble those of *E. hæmastoma* and *E. coriacea*.



**Habitat.**—The Coast district north from Sydney, N.S.W.

**REMARKS.**—The early fruits of this species have a remarkable resemblance to those of *E. acmenioides*, Schau., in fact, so much so, that in herbarium material, the two very probably on this character have been confounded in the past. The two species differ, however, considerably in the shape, texture, colour, and venation of the leaves, as well as in the mature fruits, which have a broad rim. *E. acmenioides*, Schau., has thin leaves, with a pale under-surface, which undoubtedly resemble those of *Acmena* (*Eugenia* as now understood), but those of *E. umbra* are of a uniform colour on both sides, longer and broader, and with a very marked venation much like that of *E. patentinervis*, R.T.B. The abnormal leaves are also quite distinct from those of *E. acmenioides*. The bark is lighter-coloured.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained at Gosford, N.S.W., in August, 1899. The yield of oil was 0.6 per cent. The crude oil was of a light amber colour, and had an odour resembling those of the pinene-cineol class generally. Pinene was present in quantity, but phellandrene was absent. Cineol was also a pronounced constituent. The higher boiling portions consisted largely of the sesquiterpene, and eudesmol was not detected. Although resembling in general characters the oil of *E. carnea*, yet it contained much less ester and considerably more cineol, and it thus appears that these two trees are not identical species.

The crude oil had specific gravity at 15° C. = 0.8970; rotation  $\alpha_D + 18.7^\circ$ ; refractive index at 20° = 1.4639, and was soluble in 5 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 7.1.

On rectification, 2 per cent. distilled below  $162^{\circ}$  C. (corr.). Between  $162-172^{\circ}$ , 71 per cent. distilled; between  $172-193^{\circ}$ , 20 per cent. came over; and between  $193-265^{\circ}$ , 2 per cent. distilled. The two first fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8880; rotation  $a_D + 21.2^{\circ}$ .

Second " " " " = 0.9083; " "  $a_D + 9.7^{\circ}$ .

The cineol was determined by the phosphoric acid method in the portion distilling below  $193^{\circ}$ . The result was 31 per cent., indicating about 28 per cent. in the original oil (O.M.).

The above sample was stored in the dark, and in December, 1919, was again analysed. Very little alteration had taken place during the twenty years the oil had been kept. 90 per cent. distilled below  $193^{\circ}$ . The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.8983; rotation  $a_D + 18.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4643.

Rectified portion " " = 0.8920; rotation  $a_D + 19.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4619.

The cineol was determined by the resorcinol method in the portion distilling below  $193^{\circ}$ . When calculated for the original oil the result was 42 per cent. By the rapid phosphoric acid method it was 35 per cent. when calculated for the crude oil.

## 25. *Eucalyptus santalifolia*.

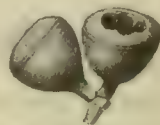
(F.v.M., in Trans. Vic. Inst., i, 35, 1855.)

White Mallee.

**Systematic.**—Tall shrub, bark greyish, smooth. Normal leaves scattered, thick, narrow, rarely broad, lanceolate, usually falcate, average about  $4\frac{1}{2}$  inches long by  $\frac{3}{4}$  inch broad, marginal vein well removed from the edge, venation oblique. Oil glands numerous, but not prominent. Petioles angular. Buds almost sessile, in axillary umbels of usually three to five, common peduncle, up to 4 lines long. Calyx tube nearly hemispherical, turbinate, slightly shorter than the conical operculum.

**Fruit.**—Hemispherical, turbinate; rim broad, truncate to domed; valves scarcely exserted; about 5 lines in diameter.

*The average domed fruit much resembles E. macrorhyncha, but is larger. The truncate and larger form is not unlike that of E. resinifera.*



**Habitat.**—Victoria, South Australia, Western Australia.

**REMARKS.**—Mueller, in his "Eucalyptographia," discards the name of *E. diversifolia* bestowed on this species by Bonpland, in favour of *E. santalifolia*, stating that the material described under that name was too imperfect for the specific classification, a determination upon which we agree, as in these days of exact science it is essential that there should be no doubt upon which the chemical data are based, and so we prefer not to accept Bonpland's nomenclature; Maiden, however, accepts it in his "Critical Revision," Vol. 1, p. 197. Our reasons for the systematic placing of this species is more fully dealt with in our paper on South Australian Eucalypts, Roy. Soc., S.A., vol. xi, p. 470.



**ESSENTIAL OIL.**—Material consisting of leaves and terminal branchlets for distillation was collected at the Kingscote end of Kangaroo Island, in June, 1911. The yield of oil was 0.41 per cent. The crude oil was of a lemon-yellow colour and had a terpene-like odour, which almost entirely masked that of the small amount of cineol. Although chiefly a terpene oil, and highly *lavo*-rotatory, yet phellandrene was absent. The oil also contained nearly 20 per cent. of sesquiterpene. The crude oil had specific gravity at 15° C. = 0.884; rotation  $a_D$  — 37.7°; refractive index at 20° = 1.4736, and required 8 volumes 80 per cent. alcohol to form a clear solution. The saponification number for the esters and free acid was 4.9.

On rectification, a few drops of acid water and volatile aldehydes came over below 168° C. (corr.). Between 168–175°, 38 per cent. distilled; between 175–200°, 39 per cent. came over; and between 260–275°, 17 per cent. distilled. These fractions gave the following results:—

|                                   |                                                                     |
|-----------------------------------|---------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. | = 0.8674; rotation $a_D$ — 38.6°; refractive index at 20° = 1.4670. |
| Second     "     "     "          | = 0.8701; rotation $a_D$ — 52.2°; refractive index at 20° = 1.4691. |
| Third     "     "     "           | = 0.9295; rotation not taken; refractive index at 20° = 1.4963.     |

The cineol was determined by the resorcinol method in the portion distilling below 200° C.; the result was 12 per cent. when calculated for the crude oil.

The oil was thus shown to consist largely of terpenes, so that redistillation of the two first fractions was undertaken. 3 per cent. of the first fraction was removed, boiling below 162°; the second fraction was then added, and the whole fractionated in order to further separate the lower-boiling terpenes. Between 162–172°, 34 per cent. distilled (= second fraction); between 172–175°, 16 per cent. distilled. These fractions gave the following results:—

|                                   |                                                                     |
|-----------------------------------|---------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. | = 0.8597; rotation $a_D$ — 29.6°; refractive index at 20° = 1.4673. |
| Second     "     "     "          | = 0.8574; rotation $a_D$ — 48.0°; refractive index at 20° = 1.4693. |
| Third     "     "     "           | = 0.8574; rotation $a_D$ — 65.6°; refractive index at 20° = 1.4711. |

These results suggest that as phellandrene was absent the principal terpene in the oil of this species was *lavo*-rotatory limonene, and that pinene was only present in small quantity. Although the constants are those suggestive of limonene, yet the characteristic tetrabromide was not at all satisfactorily prepared. For industrial purposes the essential oil of this *Eucalyptus* has little commercial value at present.

The results obtained with the oil of this species were published by us in the *Trans. Roy. Soc., South Australia*, 1916.

## 26. *Eucalyptus Blaxlandi*.

(J.H.M. & R.H.C., Roy. Soc., N.S.W., 1918, p. 495; Desc., in Proc. Linn. Soc., N.S.W., 1905, p. 193, under *E. capitellata*.)

**Systematic.**—A tree of medium size, bark not typically stringy, but inclined to that of "Peppermint." Abnormal leaves ovate-lanceolate, margins undulate and with a reddish rim when fresh; young branchlets and foliage rough, owing to presence of stellate hairs. Normal leaves ovate-lanceolate to lanceolate, unequal at the base, thick, coriaceous, acuminate; venation indistinct, intramarginal vein not far removed from the edge, lateral veins inclined at about  $30^\circ$  to the mid-rib. Flowers in heads of about ten, borne on thick, angular peduncles, varying up to 1 inch in length. Buds clavate; calyx tube pyriform, 2 to 3 lines long; operculum compressed, hemispherical, obtuse.

**Fruit.**—Sessile, compressed, hemispherical; rim broad, domed; valves exserted; about 4 lines long and 6 lines in diameter.

*The fruits cannot be separated in herbarium material from those of E. capitellata.*



**Habitat.**—Blue Mountains, Blackheath, Mount York, Wombeyan Caves, New England, New South Wales; Gippsland, Victoria.

**REMARKS.**—It requires a field knowledge of the barks and a chemical test of the oils to differentiate the species from *E. capitellata*, as the two are very closely related.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were collected at Blackheath, N.S.W., in April, 1914. The yield of oil was 0.83 per cent. The crude oil was of a dark-amber colour, and had a pronounced turpentine-like odour. Pinene was present in considerable quantity, but phellandrene was absent. Cineol was present, but esters were in small amount, and eudesmol not detected.

The crude oil had specific gravity at  $15^\circ \text{C.} = 0.8881$ ; rotation  $a_D + 11.0^\circ$ ; refractive index at  $20^\circ = 1.4653$ , and was soluble in 6 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.8. After acetylation the value was 63.4, and in the cold with two hours' contact, 48.8. The esterised oil was particularly aromatic.

On rectification, 1 per cent. distilled below  $158^\circ \text{C.}$  (corr.). Between  $158-172^\circ$ , 77 per cent. distilled; and between  $172-188^\circ$ , 14 per cent. came over. The thermometer then rose quickly to  $257^\circ$ , between which temperature and  $267^\circ$ , 3 per cent. distilled. These fractions gave the following results:—

|                 |                                 |              |                               |                                           |
|-----------------|---------------------------------|--------------|-------------------------------|-------------------------------------------|
| First fraction, | sp. gr. at $15^\circ \text{C.}$ | $= 0.8794$ ; | rotation $a_D + 11.2^\circ$ ; | refractive index at $20^\circ = 1.4642$ . |
| Second          | " "                             | $= 0.9025$ ; | rotation $a_D + 8.5^\circ$ ;  | refractive index at $20^\circ = 1.4644$ . |
| Third           | " "                             | $= 0.9364$ ; | rotation not taken;           | refractive index at $20^\circ = 1.4949$ . |



The cineol was determined by the resorcinol method in the portion distilling below 188°. When calculated for the crude oil the result was 22 per cent. By the rapid phosphoric acid method it was 21 per cent. when calculated for the crude oil.

*The Pinene.*—A portion of the first fraction was shaken with 50 per cent. resorcinol to remove the cineol, the remaining oil fractionated, and the portion distilling below 158° separated. The nitrosochloride prepared with this melted at 104° C., thus confirming the previous indications for pinene.

## 27. *Eucalyptus microcorys*.

(F.v.M., Frag. ii, 50.)

**Tallow-wood.**

**Systematic.**—A tall tree, with a pale-coloured flatish, broken bark, branchlets quadrangular. Abnormal leaves ovate, about 3 inches long, acuminate, membranous, pale on the under surface; venation distinct, lateral veins very spreading, intramarginal vein removed from the edge. Normal leaves lanceolate, varying in length up to 6 inches or longer, rather thicker than the earlier leaves, pale on the underside; venation distinct, lateral veins spreading, intramarginal one removed from the edge. Oil dots very numerous. Peduncles, flattened, axillary or in short terminal panicles or corymbs, generally about six flowers in the head. Calyx small, pedicel slender, 4 to 6 lines long; operculum small, domed.

**Fruit.**—Conical, elongated, rarely cylindrical, sometimes angular at the base; double-rimmed; valves slightly exserted; about 6 lines long, 3 lines in diameter.



*Somewhat resemble those of E. Fergusoni in shape, but smaller, and with a thicker rim.*

**Habitat.**—Northern Coast district of New South Wales and into Queensland.

**REMARKS.**—A well-marked and distinct species, characterised chiefly by its pale-coloured, hard, durable, greasy-natured timber. Bark pale-coloured or yellowish, not ridged. It appears to be always known vernacularly as "Tallow-wood," and is never confounded by settlers and timber-getters with any other species. The leaves have a great resemblance to those of *E. ochrophloia* of the north-west interior of New South Wales, and Bentham's placing of Fraser's specimens from that locality under *E. microcorys*, B. Fl. iii, 213, is very probably an error, as *E. microcorys*, as at present understood, does not occur west of the Main Dividing Range. Fraser's species are probably *E. ochrophloia*, F.v.M. Bentham may have been misled by the morphology of the species and also probably not having sufficient field notes from collectors to guide him to a correct determination.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Tumbulgum, N.S.W., in October, 1897. The yield of oil was 0.51 per cent. The crude oil was but little coloured, had a turpentine-like odour, and was turbid. After the lapse of some years the oil still remained turbid. It may be, perhaps, that this turbidity is associated in some way with the increased cineol content that takes place in many oils of this class on keeping, particularly as an increase in cineol was noticeable even after storing the oil for only three years. When it was first distilled the amount of cineol



present in the oil was but small, the principal constituent being dextro-rotatory pinene, and it is worthy of notice that in practically all the cineol-pinene oils which form a deposit on keeping, the pinene has an optical rotation to the right. The alteration which takes place, however, is not due to the pinene, because the strictly pinene oils like that of *E. dextropinea*, for instance, do not form a deposit, and do not increase in cineol content on keeping. (See also the article in this work dealing with this deposit.) Phellandrene does not occur in the oil of this species, nor is it to be expected, judging from the botanical characters. The amount of esters was larger than is usual in oils of this class. The higher boiling portion contained some sesquiterpene. The pinene was separated and its chemical characters determined.

The crude oil had specific gravity at 15° C. = 0.895; rotation  $a_D + 18.3^\circ$ ; refractive index at 20° = 1.4690, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 19.6.

On rectification, 2 per cent. distilled below 159° C. (corr.). This portion contained the usual amount of volatile aldehydes. Between 159–169°, 60 per cent. distilled; between 169–178°, 24 per cent. distilled; and between 178–204°, 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.879; rotation  $a_D + 23.6^\circ$ ;  
 Second     "     "     "     "     = 0.897;     "     "     + 13.18°.  
 Third     "     "     "     "     = 0.903;     "     "     not taken.

The cineol was not present in sufficient amount to allow of its being determined quantitatively by the phosphoric acid method, and the resorcinol method was not then available.

The above sample of oil had been stored in the dark, and in April, 1919, was again analysed. An increase in cineol content was shown, and this is more noticeable in the redistilled oil. 86 per cent. distilled below 190° C. The crude oil and the fraction gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9144; rotation  $a_D + 17.4^\circ$ ; refractive index at 20° = 1.4688.

Fraction     "     "     "     "     = 0.9140; rotation  $a_D + 18.2^\circ$ ; refractive index at 20° = 1.4640.

The cineol was determined by the resorcinol method in the rectified portion, and calculated for the crude oil; the result was 49 per cent. By the rapid phosphoric acid method it was 30 per cent. when calculated for the crude oil.

## 28. *Eucalyptus hemilampra*.

(F.v.M., Herb.; R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 669.)

(Syn. *E. resinifera*, Sm. var. *grandiflora*, Benth., B.Fl., iii, 246.)

**Mahogany.**

**Systematic.**—A very tall tree, with a red, stringy bark. Abnormal leaves of the same shape as the mature ones. Normal leaves broadly lanceolate, 6 to 9 inches long, shining above, pale underneath, of a thick texture; venation indistinct, lateral veins numerous, inclining to transverse, more prominent on the under side of the leaf, intramarginal vein close to the edge; petiole 2 inches

long, channelled above. Oil glands quite obscured. Umbels axillary, peduncle flattened, about 1 inch long, bearing mostly seven flowers. Calyx pyriform, angular, pedicel short, 2 to 3 lines long; operculum rather larger than the calyx, hemispherical, either shortly acuminate or rostrate.

**Fruit.**—Hemispherical to turbinate, angular at the base; valves prominently exserted; rim up to  $1\frac{1}{2}$  lines broad; 8 lines in diameter, and 9 lines in length.

*The fruits are characteristic, the flat rim having the appearance of protruding from the capsule for nearly  $\frac{1}{8}$  of an inch. Easily determined by the figure here given.*



**Habitat.**—Manly; South Coast district of New South Wales.

**REMARKS.**—The tree, as stated above, was placed by Bentham (*loc. cit.*) as a variety of *E. resinifera* of Smith, and although the venation and the shape of the leaves of the two trees resemble each other, the fruits and timber are distinct and quite constant, and it is on these characters that the species was separated from *E. resinifera*, Sm.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Currawang Creek, N.S.W., in July, 1898. The yield of oil was 0.37 per cent. The crude oil was of a reddish-brown colour, and had an odour resembling the pinene-cineol oils generally. Volatile aldehydes were pronounced, in which valeraldehyde occurred. Pinene was the chief terpene, and phellandrene was absent. Cineol was present in some quantity, and esters also. The higher boiling portion consisted largely of the sesquiterpene.

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9282$ ; rotation  $a_D + 7.09^{\circ}$ , refractive index at  $20^{\circ} = 1.4678$ , and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 24.4 per cent.

On rectification, 2 per cent. distilled below  $169^{\circ}\text{C.}$  (corr.). Between  $169$ – $183^{\circ}$ , 78 per cent. distilled; between  $183$ – $245^{\circ}$ , 10 per cent. came over; and between  $245$ – $262^{\circ}$ , 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9122$ ; rotation  $a_D + 6.82^{\circ}$ .

Second „ „ „ „ =  $0.9252$ ; „ not taken.

Third „ „ „ „ =  $0.9342$ ; „ „

The cineol was determined by the phosphoric acid method in the first fraction; 43 per cent. of that constituent was present, indicating about 35 per cent. in the original oil (O.M.).

The above sample had been stored in the dark, and in August, 1919, twenty-one years afterwards, was again analysed. It had increased in cineol content to quite a considerable extent. The physical characters are also in agreement with that result. The crude oil and the rectified portion gave the following results. 86 per cent. distilled below  $190^{\circ}\text{C.}$ :—

Crude oil, sp. gr. at  $15^{\circ}\text{C.} = 0.9334$ ; rotation  $a_D + 6.7^{\circ}$ ; refractive index at  $20^{\circ} = 1.4646$ .

Fraction „ „ „ „ =  $0.9162$ ; rotation  $a_D + 5.7^{\circ}$ ; refractive index at  $20^{\circ} = 1.4599$ .

The cineol was determined by the resorcinol method and calculated for the crude oil; the result was 72 per cent. By the rapid phosphoric acid method it was 50 per cent. when calculated for the crude oil.



## 29. *Eucalyptus corynocalyx*.

(F.v.M., in *Fragm.*, ii. 43, 1860.)

**Systematic.**—A large tree reaching in favourable situations a height of 120 feet, from 4 to 6 feet in diameter at the base, and as much as 60 feet to the first branch. The average size, however, is about 80 feet in height. The bark is smooth, and after the outer layers have been shed, has a yellow-white or yellow-blue, piebald appearance. Abnormal leaves alternate, sub-rotund or ovate, short petiolate, paler underneath, about 2 inches long, and  $1\frac{1}{2}$  inch wide. Normal leaves lanceolate, thick, shining, about 5 inches long and 1 inch wide; underside paler in colour; intramarginal vein somewhat removed from the edge, lateral veins prominent, inclined at about  $45^\circ$  to the mid-rib. Oil glands not conspicuous. Flowers borne in umbels of four to sixteen, usually below the leaves, the common peduncle about  $\frac{1}{2}$  inch long. Calyx tube wrinkled, bell-shaped, 4 lines long, tapering to a short pedicel; operculum hemispherical, bluntly pointed.

**Fruit.**—Shaped like an urn or almost similar to an egg with one end cut off, ribbed longitudinally; rim narrow; valves deeply inserted; about 6 lines long, 4 lines broad.

*These fruits in general shape might be classed with E. calycogona, but the ribs are much less pronounced and the surface not so shining, nor are they so contracted below the rim.*



**Habitat.**—Victoria, South Australia.

**REMARKS.**—Mueller, when describing this *Eucalyptus* in 1860, gave it this name, which was acknowledged by Bentham in his "*Flora Australiensis*," vol. iii, p. 218 (1886). It appears, however, that in 1852 Mueller had already described the same species under the name of *E. cladocalyx*, but discards this for *E. corynocalyx* in his "*Eucalyptographia*," 1879, and Bentham follows his wishes. He must evidently have had some sound reason for such alteration of nomenclature, and now that the name of *E. corynocalyx* runs through *Eucalyptus* literature of the last fifty years, we have decided to fall into line with the author's wishes and use the name *E. corynocalyx*, and not that of *E. cladocalyx*.

**ESSENTIAL OIL.**—Material consisting of leaves and terminal branchlets for distillation was collected at the Kingscote end of Kangaroo Island, in June, 1911. The yield of oil was very small, only 3 oz. being obtained from 194 lb. of material, equal to 0.096 per cent. The crude oil was of an orange-brown colour, and the odour resembled that of an oil belonging to the cineol-pinene group. The secondary odour was indefinite. Phellandrene does not occur in the oil of this species. The crude oil had specific gravity at  $15^\circ$  C. = 0.8945; rotation  $\alpha_D + 8.1^\circ$ ; refractive index at  $20^\circ$  = 1.4779, and was soluble in 4 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 7.7.

On rectification, a few drops of acid water, with some aldehydes, came over below  $159^\circ$  C. (corr.). Between  $159$ – $167^\circ$ , 28 per cent. distilled, and between



167–205°, 53 per cent. came over; the residue thus represented 19 per cent. As the amount of oil was small, less than half the usual quantity was available for distillation. These fractions gave the following results:—

|                 |                                                                                                  |
|-----------------|--------------------------------------------------------------------------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8718; rotation $\alpha_D + 20.9^\circ$ ; refractive index at 20° = 1.4670. |
| Second          | " " " = 0.8816; rotation $\alpha_D + 11.1^\circ$ ; refractive index at 20° = 1.4738.             |
| Residue         | " " " = 0.9548; rotation not taken; refractive index at 20° = 1.5007.                            |

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 20 per cent. The oil of this species has a strong resemblance to those distilled from *E. microcorys* and *E. maculata*. The chief terpene was dextro-rotatory pinene. The species has little value as an oil-producing Eucalypt.

The results obtained with the oil of this species were published by us in the Trans. Roy. Soc., South Australia, 1916.

### 30. *Eucalyptus fasciculosa*.

(F.v.M., in Trans. Vic. Inst., 34, 1855.)

White Gum.

**Systematic.**—A small tree, seldom more than 30 feet in height, with a smooth bark. Abnormal leaves broad, nearly ovate. Normal leaves lanceolate, thick, or coriaceous, about 5 inches long and 1 inch broad; intramarginal vein removed from the edge, venation obscure, but inclined at about 45° to the mid-rib. Oil glands not apparent. Flowers in paniculate umbels of about three to five flowers. Calyx tube tapering, short pedicel; operculum blunt, conical, much shorter than the calyx tube.

**Fruit.**—Conoidal, wrinkled, shining; rim thin, horizontal, often with transverse cracks; valves inserted, about 4 lines long and 2 lines broad. In one form the fruit is inclined to be semi-ovate; rim double, the inner being deciduous.



*These fruits so resemble those of E. paniculata that on morphological grounds it was long confounded with that species. They also are not unlike E. polyanthemus and E. Fletcheri, in a few instances.*

**Habitat.**—Victoria and South Australia.

**REMARKS.**—Mueller described this tree in Trans. Vic. Inst., vol. 34, but Bentham, 1866, "Flora Australiensis," vol. iii, p. 212, synonymises it under *E. paniculata*. Mueller in his "Eucalyptographia," 1879, concurs in such a classification, but Maiden, in Trans. Roy. Soc. S. Aus., 1908, p. 280, shows that these two are distinct, and as this is not an "Ironbark," they should be separated. It is another instance proving that something more is required in the specific determination of Eucalypts than a morphological comparison of the leaves, fruits, &c. J. E. Brown figures and describes it in his "Forest Flora of South Australia," p. 46, under the name of *E. paniculata*. There can be no doubt that the flowers, leaves and fruits there figured much resemble *E. paniculata*, and there is also a strong connection in the chemistry of the oils of the two species, but the timbers, bark, and habitat well indicate the specific differences.

**ESSENTIAL OIL.**—Material consisting of leaves and terminal branchlets was received for distillation from the Conservator of Forests of South Australia (Mr. Walter Gill), in December, 1911.

The yield of oil was 0.02 per cent., only 1 oz. of oil being obtained from 329 lb. of material. The species is thus a very poor oil-producing Eucalypt. The crude oil was somewhat mobile, of a dark-amber colour, and with an odour indicating an oil of the pinene-cineol group. The amount of cineol was small; certainly not more than about 15 per cent. of that constituent being present. The saponification number for the esters and free acid was 22.1, which, for an alcohol belonging to the  $C_{10}H_{17}OH$  series, in combination with acetic acid, represents 7.7 per cent. of ester. The odour of the separated oil was not distinctive, and did not indicate geraniol, so that the identity of the alcohol is at present in doubt. Possibly it may be terpineol.

The crude oil had specific gravity at 15° C. = 0.9041; rotation  $\alpha_D + 6.3^\circ$ ; refractive index at 20° = 1.4789, and was scarcely soluble in 10 volumes 80 per cent. alcohol.

The small amount of oil at our disposal did not permit of more extensive investigation, and distillation results were not obtained. The species has no value as an oil producing tree, the yield of oil being so small.

The results obtained with the oil of this species were published by us in the Trans. Roy. Soc., South Australia, 1916.

### 31. *Eucalyptus megacarpa*.

(F.v.M., Fragn., ii, 70.)

**Blue Gum.**

(The "Blue Gum" of Donnybrook, or the "Bullich" of the Jarrah Belt, W.A.)

**Systematic.**—A medium-sized tree, bark smooth when fresh, but becoming rough on exposure. Abnormal leaves elliptical ovate, about 4 inches long and 2 inches wide, shortly petiolate. Normal leaves lanceolate, 4 to 6 inches long, falcate, thick, shining; venation not conspicuous, lateral veins oblique and fine, intramarginal vein somewhat removed from the edge. Peduncles axillary or lateral, short, thick, flat, each bearing one to three sessile flowers. Calyx tube broad, turbinate, under 6 lines long, slightly longer than the conical or hemispherical, short pointed operculum.

**Fruit.**—Hemispherical, large, ribbed, or almost smooth; rim narrow, slightly convex, continuous with the thick, conical, obtuse, incurved valves;  $\frac{3}{4}$  to 1 inch in diameter.

*They have some resemblance to E. globulus in general shape and surface, but not in the disposition of the valves.*



**Habitat.**—Western Australia.



**ESSENTIAL OIL.**—A sample of the oil of this species was forwarded to us for investigation by Mr. C. E. Lane-Poole, the Conservator of Forests of Western Australia. The oil had been distilled by Mr. Braddock of that State, who obtained a yield of 0.5 per cent.

The crude oil was mobile, of a light amber colour, with a terpene-like odour, and a secondary aromatic one. It contained a considerable quantity of pinene, but phellandrene was absent. Both limonene and terpinene were present, as was also cineol. The ester was apparently largely geranyl-acetate.

The crude oil had specific gravity at 15° C. = 0.8852; rotation  $a_D$  — 31.2°; refractive index at 20° = 1.4719; and was soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 7.5.

On rectification, 1 per cent. distilled below 160° C. (corr.). Between 160–172°, 61 per cent. distilled; between 172–193°, 28 per cent. distilled, leaving 10 per cent. of residue. The fractions and residue gave the following results:—

|                                                                                                                   |  |
|-------------------------------------------------------------------------------------------------------------------|--|
| First fraction, sp. gr. at 15° C. = 0.8740; rotation $a_D$ — 33.2°; refractive index at 20° = 1.4671.             |  |
| Second           ,,           ,,           ,, = 0.8837; rotation $a_D$ — 35.0°; refractive index at 20° = 1.4710. |  |
| Residue           ,,           ,, = 0.9521; rotation $a_D$ — 3.0°; refractive index at 20° = 1.4988.              |  |

The lower boiling portion of the first fraction gave a nitrosochloride melting at 104° C., so that pinene was present in quantity.

The second fraction contained limonene, dipentene, and terpinene.

The saponification number for the residue was 15.1, and in the cold with two hours' contact it was 9.6. The odour of the cold saponified oil was that of geraniol, so that the indication is 3.36 per cent. of geranyl-acetate in that portion.

The saponification number for the first fraction was 8.1, so that a low boiling ester, probably butyl-butyrate, was present.

The cineol was determined by the resorcinol method in the portion distilling below 193°; when calculated for the crude oil, the result was 30 per cent. As the low boiling esters were also absorbed this is somewhat in excess of the real amount, and phosphoric acid did not indicate more than about 15 per cent. in the crude oil.

See also the article in this work, "On the occurrence of Terpinene in Eucalyptus Oils."

## 32. *Eucalyptus redunca*.

(Schau., in Lehmann's Plant. Preiss., I, 127, 1844.)

### White Gum.

**Systematic.**—A shrub or small tree (reaching up to 120 feet, F.v.M., var. *elata*, Benth.), with a smooth white bark. Normal leaves ovate-lanceolate to lanceolate, sometimes acuminate, averaging about 3 inches long, thick, coriaceous, often somewhat crenulate; venation moderately distinct at times, intramarginal vein looped, much removed from the edge, lateral veins



distinct, and fairly oblique, inclined at about  $45^\circ$  to the mid-rib. Peduncles axillary or lateral, bearing dense umbels of five to fourteen flowers. Calyx tube narrow, about  $2\frac{1}{2}$  lines long, contracted into a short pedicel and shorter than the conical, acute, slightly bent operculum.

**Fruit.**—Narrow, turbinate or even sub-cylindrical; rim thin; flat; valves slightly exerted;  $3\frac{1}{2}$  lines long and 2 lines in diameter (occasionally larger than those depicted).



*In shape they nearly approach those of E. campanulata, E. accedens, or E. Consideriana, although smaller in the latter case.*

**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Material of this species for distillation was forwarded from Western Australia, in February, 1904. It was obtained at Narrogin, on the Great Southern Railway. The yield of oil was 1.2 per cent. The crude oil was red in colour, and had an odour characteristic of the cineol-pinene oils generally. Pinene was present in quantity, and it principally belonged to the dextro-rotatory form. Phellandrene was absent, and esters only present in small amount. The higher boiling portion consisted principally of the sesquiterpene, and it is doubtful if aromadendral occurs. Cineol was present in some quantity, but the excess of terpenes caused the oil to be somewhat insoluble in alcohol.

The crude oil had specific gravity at  $15^\circ \text{C.} = 0.9097$ ; rotation  $a_D + 13.5^\circ$ ; refractive index at  $20^\circ = 1.4663$ , and was soluble in 6 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.4.

On rectification, 1 per cent. distilled below  $162^\circ \text{C. (corr.)}$ . Between  $162$ – $172^\circ$ , 49 per cent. distilled; between  $172$ – $183^\circ$ , 37 per cent. came over; between  $183$ – $193^\circ$ , 4 per cent. distilled, and between  $245$ – $261^\circ$ , 3 per cent. distilled. Practically nothing distilled between  $193$  and  $245^\circ$ . The fractions gave the following results:—

|                 |                                                                          |
|-----------------|--------------------------------------------------------------------------|
| First fraction, | sp. gr. at $15^\circ \text{C.} = 0.8988$ ; rotation $a_D + 17.7^\circ$ . |
| Second          | „ „ „ = $0.9134$ ; „ + $9.7^\circ$ .                                     |
| Third           | „ „ „ = $0.9216$ ; „ + $6.6^\circ$ .                                     |
| Fourth          | „ „ „ = $0.9299$ ; „ not taken.                                          |

The cineol was determined by the phosphoric acid method in the portion distilling below  $183^\circ$ ; the result was 43 per cent. of that constituent, indicating about 38 per cent. in the crude oil (O.M.).

In September, 1918, material for distillation was received from Mr. C. E. Lane-Poole, the Conservator of Forests, Western Australia. The oil was practically in agreement with the above, except that the yield was a little less. The cineol was determined by the resorcinol method in the portion distilling below  $190^\circ \text{C.}$ ; when calculated for the crude oil, the result was 34 per cent.

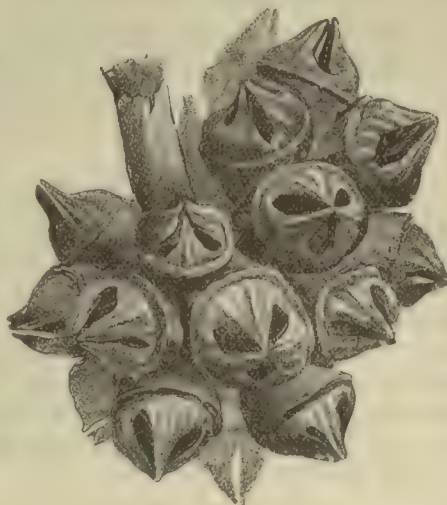
### 33. *Eucalyptus Lehmanni*.

(Preiss. Herb., according to Schau., in Pl. Preiss, Vol. I, p. 127, 1845.)

**Systematic.**—A tall shrub or small tree, with a roughish, reddish bark coming off in irregular sheets (Oldfield). Abnormal leaves orbicular to oval, small, thin, petiolate. Normal leaves oblong-ovate to broad lanceolate, about  $2\frac{1}{2}$  inches long, obtuse, very thick, intramarginal vein removed from the edge, lateral veins very oblique. Flowers often twenty or more in dense heads on thick recurved, sometimes flattened peduncles, 1 to 3 inches long. Calyx tube 2 to 3 lines in diameter, more or less sunk in the receptacle; operculum cylindrical, dilated at the base, obtuse, up to  $1\frac{1}{2}$  inch long.

**Fruit.**—Numerous, adnate in a cluster of twelve to twenty, and well sunk in the receptacle; symmetry lost by compression; valves well exserted, wrinkled, acuminate, with openings between each valve, and connivent into a prominent cone, tapering into the persistent elevated base of the style; rim very narrow; about 7 lines in diameter.

*These are easily separated from E. cornuta by the absence of the receptacle enclosing the base of the adnate fruits. The figure by Hooker, Bot. Mag. 6140, under E. cornuta, is this species.*



**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Material of this species was collected from cultivated trees grown at the Werribee Sewage Farm, Victoria, in September, 1916. The oil was distilled by Mr. P. R. H. St. John, at Melbourne, who submitted it to us for investigation. The yield of oil he obtained from leaves and terminal branchlets was equal to 0.86 per cent. Mr. St. John states that no sewage matter was near the trees.

During the first hour 60 per cent. of the whole oil distilled; for the second hour 23 per cent. distilled, for the third and fourth hours 14 per cent., and for the fifth hour 3 per cent.

The crude oil was of a light lemon colour, and the odour gave a strong indication of the presence of valeraldehyde and butaldehyde. Pinene was the chief terpene, and phellandrene was absent. Cineol was present in fair quantity only. The crude oil was turbid when received, and did not clear on standing for some months; in this peculiarity it resembled that of *E. microcorys*. Only a small amount of ester was present.

The crude oil had specific gravity at 15° C. = 0.8964; rotation  $\alpha_D + 17.5^\circ$ ; refractive index at 20° = 1.4653, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 6.7.



On rectification 1 per cent. distilled below  $152^{\circ}$  C. (corr.). Between  $152-170^{\circ}$ , 55 per cent. distilled; between  $170-193^{\circ}$ , 30 per cent. came over, and between  $193-255^{\circ}$ , 9 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.885; rotation  $a_D + 23.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4601.  
 Second       "       "       "       " = 0.906; rotation  $a_D + 13.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4634.  
 Third       "       "       "       " = 0.943; rotation not taken; refractive index at  $20^{\circ}$  = 1.4821.

The saponification number for the esters in the third fraction was 13.3, and for the first fraction 6.3. It is thus evident that a low-boiling ester, perhaps butyl-butyrate, was present in the first fraction.

The cineol was determined by the resorcinol method in the portion distilling below  $193^{\circ}$  C.; when calculated for the crude oil, the result was 40 per cent. By phosphoric acid the cineol hardly exceeded 20 per cent. A considerable amount of cineol was present in the oil boiling below  $170^{\circ}$  C. The first fraction was again distilled, when 46 per cent. came over below  $159^{\circ}$  C. (corr.), and 37 per cent. between  $157-167^{\circ}$  C. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8726; rotation  $a_D + 28.9^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4625.  
 Second       "       "       "       " = 0.8864; rotation  $a_D + 24.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4649.

**THE PINENE.**—The first fraction above was shaken with a solution of 50 per cent. resorcinol to remove the cineol. The unabsorbed oil was washed, dried and redistilled, when practically the whole came over between  $156-157^{\circ}$  C. (corr.). It had specific gravity at  $15^{\circ}$  C. = 0.8636; rotation  $a_D + 38.6^{\circ}$ ; and refractive index at  $20^{\circ}$  = 1.4658. These constants are in close agreement with those for pinene. The nitrosochloride was prepared in the ordinary way and when purified melted at  $103-4^{\circ}$  C. This result confirms the indications for pinene, which thus had a specific rotation  $[a]_D + 44.69^{\circ}$ .

The oil of this species belongs to the pinene-cineol group, containing a small amount of esters.

### 34. *Eucalyptus leucoxylon*.

(F.v.M. with *E. sideroxylon* in Trans. Vic. Inst., I, 33, 1855.)

**White Gum.**

**Systematic.**—A moderately sized tree seldom exceeding 20 to 30 feet, with a smooth bark. Bark deciduous, whilst in young trees it is yellow or reddish in colour. Abnormal leaves ovate to ovate-lanceolate, sessile or shortly petiolate, often glaucous. Normal leaves ovate-lanceolate to narrow lanceolate, often thickish; intramarginal vein removed from the edge; venation oblique, sometimes 6 inches long and under  $\frac{1}{2}$  inch wide. Buds usually two to three each on





**THE TERPENES.**—When the cineol in the oil of the first two fractions was combined with phosphoric acid in excess, the terpenes separated from the thick jelly formed, and could be poured from the cineol phosphate. After agitating with 50 per cent. solution of resorcinol, the separated liquid, after well washing and drying, had specific gravity at  $15^{\circ} = 0.8641$ ; rotation  $a_D + 11.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4756$ .

The oil was tinged yellow, had an odour resembling that of cymene, and was very mobile. The terpenes were redistilled, when 50 per cent. came over between  $157-167^{\circ}$  (corr.) and 34 per cent. between  $167-172^{\circ}$ . These two fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8604; rotation  $a_D + 17.5^{\circ}$ , refractive index at  $20^{\circ} = 1.4715$ .

Second     ,,     ,,     ,,     = 0.8569; rotation  $a_D + 9.1^{\circ}$ , refractive index at  $20^{\circ} = 1.4746$ .

The nitrosochloride was readily formed with the first fraction, and this, when purified, melted at  $104^{\circ}$  C. It was thus evident that the chief terpene in the oil of this species was dextro-rotatory pinene.

The specific gravity and refractive index suggested that the other terpene was limonene or dipentene, and probably cymene was present also. The oil of this species is thus shown to contain a predominance of terpenes, and to have little value for commercial purposes.

The results obtained with the oil of this species were published by us in the Trans. Roy. Soc., South Australia, 1916.

## 35. *Eucalyptus rudis*.

(Endl., in Hueg. Enum., 49, 1837.)

**Systematic.**—A moderate-sized tree, the bark rough, and persistent. Abnormal leaves ovate, petiolate; normal leaves lanceolate, often falcate, acuminate, about 4 inches long, intramarginal vein not far removed from the edge, lateral veins distant, inclined at about  $45^{\circ}$  to the mid-rib. Peduncles axillary or lateral, about 6 lines long, bearing umbels of three to eight flowers. Calyx tube turbinate, 3 lines long, tapering to a pedicel of equal length; operculum conoidal, often longer than the calyx tube.

**Fruit.**—Broad, turbinate or bell shaped, dilated at the top, particularly so in the younger stages; rim truncate or very slightly convex; valves much exserted; 3 to 5 lines long and 5 to 6 lines in diameter.



*E. patentinervis*, an eastern species, more closely matches this than any other, but is not quite so large.

**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were forwarded by Mr. C. E. Lane-Poole, the Conservator of Forests, Western Australia. The material was collected at Donnybrook, W.A., January, 1919. The yield of oil was 1.2 per cent.



The crude oil was of a dark amber colour, and had an odour similar to those of pinene-cineol oils generally. Volatile aldehydes were pronounced. The pinene was dextro-rotatory, and phellandrene was absent. Cineol was present in fair amount. Esters were in small quantity, but those present were high-boiling. A small amount of the sesquiterpene was also present.

The crude oil had specific gravity at 15° C. = 0.9068; rotation  $a_D + 10.1^\circ$ , refractive index at 20° = 1.4695, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 3.2.

On rectification 1 per cent. distilled below 162° C. (corr.). Between 162–172°, 50 per cent. distilled; between 172–193°, 30 per cent. came over, leaving 19 per cent. boiling above 193°. The two fractions and the residue gave the following results:—

|                                      |                                                                                             |
|--------------------------------------|---------------------------------------------------------------------------------------------|
| First fraction,                      | sp. gr. at 15° C. = 0.8940; rotation $a_D + 15.7^\circ$ ; refractive index at 20° = 1.4633. |
| Second        ,,        ,,        ,, | = 0.9082; rotation $a_D + 7.6^\circ$ ; refractive index at 20° = 1.4648.                    |
| Residue        ,,        ,,          | = 0.9409; rotation too dark; refractive index at 20° = 1.4905.                              |

The cineol was determined by the resorcinol method in the portion distilling between 162–193°; when calculated for the crude oil, the result was 45 per cent. A determination by the rapid phosphoric acid method gave 38 per cent.

The saponification number for the residue was 11.3, and in the cold with two hours' contact it was 8.3.

The phenols were removed in the ordinary way; they were liquid and gave the reaction for tasmanol. The amount of phenols present in the crude oil was 0.18 per cent.

The rectified oil was yellowish in tint, a character common to the oils of this class. This colour is probably due to the influence of the phenol australol.

### 36. *Eucalyptus maculata*.

(Hooker, Ic. Pl., t., 619.)

#### Spotted Gum.

**Systematic.**—A tall tree, with a long clean trunk. Bark smooth, somewhat shining, whitish or sometimes reddish-grey, mottled by bluish-white or brown-reddish spots, indicating the places or rudiments of patches of older bark, hence the vernacular name. Abnormal leaves sometimes 1 foot long and 3 inches broad, thick, pale on the under side, venation similar to that of the normal leaves, which are long, lanceolate, slightly falcate, from 4 to 6 inches long; venation distinct, fine, oblique, parallel; intramarginal vein close to the edge, somewhat obscured. Flowers in axillary or terminal panicles, on pedicels 2 to 3 lines long. Calyx oblong or cylindrical, 3 to 4 lines in diameter; outer operculum hemispherical but depressed, either with or without a small point.

**Fruit.**—Urn-shaped; rim thin, sunk; valves inserted; about  $\frac{1}{2}$  inch long.

*It is almost similar in shape to that of E. citriodora, and uncommonly resembles the smaller fruited form of the "Bloodwood" species.*

**Habitat.**—Coastal Districts, and Tableland from Clyde River, N.S.W., into Queensland.





**REMARKS.**—One of the best known trees in the coast district of these States. The common term "Spotted Gum" is a little confusing, as several other species with a smooth bark are known by that name. The Queensland tree *E. citriodora* was at one time placed as a variety of *E. maculata*, but the analogy is only in the shape of the fruits. The two otherwise are quite distinct. The chief economic of *E. maculata* is its timber, which is largely used locally for coachbuilding. It is a splendid bending wood.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Currawang Creek, N.S.W., in July, 1898. The yield of oil was 0.23 per cent. The crude oil was of a light orange-brown colour, and had a turpentine-like odour, with an aromatic secondary one. A somewhat large amount of pinene was present, but phellandrene was absent. Cineol occurs in fair amount. The third fraction consisted largely of the sesquiterpene. The predominance of the terpenes accounts for the comparative insolubility of the oil in alcohol, it requiring 1 volume of 80 per cent. alcohol to form a clear solution. The aldehyde citronellal does not appear to occur in the oil of this species even in traces, so that in cases where this aldehyde has been recorded for the oil of *E. maculata*, that of *E. citriodora* had been worked upon.

The crude oil had specific gravity at 15° C. = 0.9201; rotation  $a_D + 7.7^\circ$ ; refractive index at 20° = 1.4804. The saponification number for the esters and free acid was 9.5.

On rectification, 2 per cent. distilled below 166° C. (corr.). Between 166–183°, 43 per cent. distilled; between 183–260°, 22 per cent. came over, and between 260–280°, 27 per cent. distilled. The last fraction consisted very largely of the sesquiterpene. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8925; rotation,  $a_D + 14.01^\circ$ .

Second " " " " = 0.9020; " " " " + 8.9°.

Third " " " " = 0.9431; " " " " + 3.58°.

The cineol was determined by the phosphoric acid method in the first fraction. The result was 39 per cent., which represents about 18 per cent. in the crude oil (O.M.).

To test the constancy of the oil products of this species material was obtained from Woodburn, in the north-east corner of New South Wales, the previous consignment having come from the south-eastern portion of that State. The oil was distilled in September, 1901, so that more than three years separate the two distillations. There was a close agreement between the two samples of oil, the physical and chemical characters being in accord. The higher specific gravity of the Currawang Creek sample was due to a larger amount of the sesquiterpene. Pinene was present in quantity, but phellandrene was absent. The cineol determined by the phosphoric acid method gave 20 per cent. (O.M.). The specific gravity of the crude oil at 15° C. = 0.8959; optical rotation  $a_D + 5.1^\circ$ . The saponification number of the esters was 6.5. The crude oil required 4 volumes 80 per cent. alcohol to form a clear solution.

The sample from Woodburn had been stored in the dark, and in August, 1919, was again analysed. But little change had taken place in the crude oil during the eighteen years it had been kept. The crude oil and the fraction gave the following results. 60 per cent. distilled below 190° C.:—

Crude oil, sp. gr. at 15° C. = 0.9095; rotation  $a_D + 5.0^\circ$ ; refractive index at 20° = 1.4814.

Fraction " " " " = 0.8877; rotation  $a_D + 4.5^\circ$ ; refractive index at 20° = 1.4701.

The cineol was determined by the resorcinol method in the fraction, and calculated for the crude oil; the result was 25 per cent. By the rapid phosphoric acid method it was 21 per cent. when calculated for the crude oil.

### 37. *Eucalyptus intertexta*.

(R.T.B., Proc. Linn. Soc., 1900, p. 308, t. XVII.)

**Spotted Gum, Gum, Coolabah.**

**Systematic.**—A large tree, up to 80 feet high, and 3 feet or more in diameter. Bark smooth, nearly to the ground; butt-bark hard and persistent, extending a few feet up the trunk; the smooth bark has patches, or spots, and varies much in colour, from brownish, to all shades of a lighter grey, and sometimes to quite chalky white. Leaves lanceolate-acuminate, mostly under 6 inches long, of a pale yellowish, or sometimes bluish colour on both surfaces, not shining; lateral veins spreading, but not prominent, and almost quite hidden, intramarginal vein close to the edge. Buds on slender pedicels from 4 to 6 lines long. Flowers numerous, mostly in a terminal panicle. Calyx small, pyriform; operculum hemispherical or conical, sometimes shortly acuminate.

**Fruit.**—Variable in shape, sometimes cylindrical, pyriform, with the thin rim incurved, whilst at other times pilular in form, with a constriction below the rim; valves inserted; 2 to 3 lines in diameter.



*The pyriform variety is very much like E. paniculata; the coarser form like E. odorata; the pilular form E. pallens, and the small variety E. polybractea.*



**Habitat.**—New South Wales, Dubbo to the Darling River ("Gum"); Nymagee, Condobolin ("Coolabah"); Mt. Hope ("Yellow Jacket" and "Gum"); Cobar ("Coolabah," "Gum"); Drysdale ("Coolabah"); Bodabah, 30 miles east of Nymagee. Mr. Maiden, Cr. Rev. Vol. IV, pt. 6, pp. 170 to 172, records it from South Australia, Western Australia, and Northern Territory.

**Timber.**—Timber very hard and red in colour, and very much interlocked, in fact, so much so that it is stated to be almost impossible to split; and though being in good repute for durability, it is very little used owing to this difficulty in cleaving. It should be a good timber for railway sleepers.

**REMARKS.**—*Eucalyptus bicolor*, which occurs in the same districts, is also known occasionally by the vernacular name of "Coolabah," but in the field there can be no doubt as to these being distinct species. *E. bicolor* is a "Box Tree," with the usual "Box" bark, and characteristic "Box" timber; but this species has a smooth bark and reddish timber. The two trees are readily distinguished by the settlers. The name "Coolabah" attached to this and a few other species is evidently an error, since the true "Coolabah" is an *Angophora* (*A. melanoxylon*, R.T.B.), which occurs at Coolabah, the town of that name on the Western Railway line. This *Eucalypt* is at Coolabah also, where it is known as "Gum," and not "Coolabah." The meaning of the aboriginal name "Coolabah"—a gnarled knotted tree—applies eminently more to the *Angophora* than to *E. bicolor* or this species. The specific name has reference to the close, interlocked timber.

**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were collected at Nyngan, New South Wales, in December, 1899. The yield of oil was 0.2 per cent. The crude oil was of a light orange-brown



colour, and had an odour resembling the cineol-pinene oils generally. Pinene was the principal terpene, and phellandrene was absent. The oil contained a fair amount of cineol. The third fraction consisted principally of the sesquiterpene.

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9076$ ; rotation  $a_D + 10.25^{\circ}$ ; refractive index at  $20^{\circ} = 1.4691$ , and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.9.

On rectification 2 per cent. distilled below  $165^{\circ}\text{C.}$  (corr.). Between  $165\text{--}185^{\circ}$ , 82 per cent. distilled; between  $185\text{--}255^{\circ}$ , 6 per cent. came over, and between  $255\text{--}270^{\circ}$ , 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9016$ ; rotation  $a_D + 12.24^{\circ}$ .

Second „ „ „ „ =  $0.9186$ ; „ „ not taken.

Third „ „ „ „ =  $0.9316$ ; „ „ „

The cineol was determined by the phosphoric acid method in the large fraction. The result was 42 per cent. of that constituent, indicating about 35 per cent. in the original oil (O.M.).

Material of this species was obtained from Girilambone, New South Wales, in March, 1900. The oil differed in no respects from that distilled from the Nyngan leaves. The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9078$ ; rotation  $a_D + 9.71^{\circ}$ , and was soluble in  $2\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.4.

The cineol determined in the crude oil by the phosphoric acid method was 35 per cent. (O.M.).

Material was also obtained from Gunbar, New South Wales, in December, 1900. The results from the oil agreed entirely with those of the above samples.

The mixed oils of the above had been kept in the dark, and in October, 1919, the sample was again analysed. The oil had increased in specific gravity, and in cineol also, and that constituent was present at this time in some quantity. The specific gravity at  $15^{\circ}\text{C.} = 0.9331$ ; rotation  $a_D + 10^{\circ}$ , and refractive index at  $20^{\circ} = 1.4671$ . 84 per cent. distilled below  $190^{\circ}$ . This fraction had sp. gr. at  $15^{\circ}\text{C.} = 0.9145$ ; rotation  $a_D + 7.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4613$ .

The cineol determined by the resorcinol method in the fraction, and calculated for the crude oil, was 65 per cent. By the rapid phosphoric acid method it was 60 per cent., when calculated for the crude oil.

### 38. *Eucalyptus lactea*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 691, t. XLVI, fig. 5.)

#### A Spotted Gum.

**Systematic.**—A fair-sized tree, with a dirty, flaky bark, which is occasionally smooth. Abnormal leaves ovate, lanceolate; normal leaves lanceolate, up to 6 inches long, and varying in breadth up to 9 lines, straight or falcate, not shining, of the same shade of green on both sides; petiole under 1 inch long; venation fairly well marked, veins oblique, spreading; the distinct, intramarginal vein



removed from the edge. Oil dots numerous. Peduncles axillary, with few flowers (five to seven) in the head, occasionally only three. Calyx hemispherical, shortly acuminate.

**Fruit.**—Hemispherical to oblong; rim, together with the valves, domed and leaving only a slight aperture to the ovary, or it is sometimes thin and the valves exerted and wide-spreading.



*Very difficult to determine from E. viminalis in most instances. The specimen depicted shows the less domed or truncate rim form.*

**Habitat.** Mount Vincent, Ilford; Oberon-road, O'Connell; Southern-road, Wingello; along the main Western-road, Blackheath, and Mount Victoria, New South Wales.

**REMARKS.**—In the field this tree might be confounded with *E. viminalis*, Labill., or *E. hæmastoma*, Sm., as both these Eucalypts have a smooth bark, which, however, in this species never has the horizontal (insect) markings almost invariably occurring on *E. viminalis*, nor the "scribbles" found on *E. hæmastoma*. It has almost similarly shaped leaves in all its stages of growth, whilst the abnormal leaves of *E. viminalis* are narrow, cordate-lanceolate, sessile. The fruits differ little from those of *E. viminalis* in shape, rim, and direction of valves. The trees, too, are not found near water, as obtains almost invariably with *E. viminalis*, but on dry, stony ridges. It differs also from that species in the constituents of its oil. It resembles *E. maculosa*, R.T.B., in the shape of the fruits, but differs from it in timber and bark. The specific name refers to the copious exudation of a milky substance from the stem when the tree is cut at certain seasons of the year.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained at Ilford, New South Wales, in September, 1899. The yield of oil was 0.54 per cent. The crude oil was red in colour, and had a turpentine-like odour, far from pleasant. Pinene was the chief terpene and phellandrene was absent. Cineol was only present in small amount, about 10 per cent. It is a terpene oil, and of little commercial value. The crude oil had specific gravity at 15° C. = 0.8826; rotation nil; refractive index at 20° = 1.4845, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 8.56. The presence of cymene was indicated.

On rectification no less than 90 per cent. distilled between 165–188° C. This rectified oil had specific gravity at 15° = 0.8788; and rotation  $a_D$  — 1.16°.

Material of this species for distillation was also obtained from Braidwood, New South Wales, in October, 1898. The results with this oil were in agreement with that distilled from the Ilford leaves. The yield of oil was 0.57 per cent.

On rectification 88 per cent. distilled below 188° C. The crude and rectified oils gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.8752; rotation nil.

Rectified oil       ,,       = 0.8698;       ,,        $a_D$  — 0.52°.

The saponification number for the esters and free acid was 11.5, and it was soluble in 5 volumes 80 per cent. alcohol.

The mixed oils of the above had been kept in the dark, and in October, 1919, the sample was again analysed. Not much alteration had taken place in the character of the oil during the 20 years it had been stored, with the exception

that the cineol had perhaps increased a little. The crude oil and traction gave the following results. 88 per cent. of the oil distilled below  $190^{\circ}$  C.:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.8813; rotation  $a_D$  —  $0.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4803.

Fraction       ,,       ,,       = 0.8771; rotation  $a_D$  —  $0.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4790.

The cineol was determined by the resorcinol method in the redistilled portion, and calculated for the crude oil; the result was 22 per cent.

The cymene was determined in the portion distilling below  $190^{\circ}$  C. The cineol was first removed by combining it with phosphoric acid, afterwards shaking the uncombined oil with 50 per cent. resorcinol. It was then washed, dried and distilled, the required fraction being separated. This had specific gravity at  $15^{\circ}$  C. = 0.8632; rotation nil; refractive index at  $20^{\circ}$  = 1.4835. A portion was oxidised by potassium permanganate in the usual way. The finally prepared acid melted at  $155$ – $156^{\circ}$  C., thus indicating p-oxyisopropylbenzoic acid, the oxidation product of p-cymene.

### 39. *Eucalyptus paludosa*.

(R T.B., Proc. Linn. Soc., N.S.W., 1898, p. 167, t. VI.)

**Yellow Gum, Swamp or Flooded Gum.**

**Systematic.**—A tree from 60 to 100 feet high, with a diameter from 2 to 3 feet. Bark brown at the butt, bluish-white on the trunk and main branches, and yellow on the smaller branches and limbs, decorticating into long ribbons of 30 feet or more, suspended from the forks and trunks of the trees. The lower young leaves opposite, sessile ovate-acuminate, rarely cordate; the upper ones petiolate, irregularly opposite, lanceolate, coriaceous, often shining, and of a yellowish-green on both sides; venation distinct. Normal leaves lanceolate-acuminate, varying in length up to 8 or 9 inches, coriaceous, slightly shining on both sides, drying a yellowish tinge; lateral veins oblique, fairly numerous and equally prominent on both sides, but in some instances scarcely visible, the intramarginal vein removed from the edge in the broader leaves, but closer in the narrower ones. Peduncles axillary, under  $\frac{1}{2}$  inch long, flattened, with seven to ten sessile flowers. Calyx tube 3 lines long; operculum conical, shortly acuminate, much shorter than the calyx tube.

**Fruit.**—Fruit shortly pedicellate, conical, truncate, with a flange just below the rim, three or four celled; valves not exserted; under 5 lines in diameter and about 4 lines in length.



*Care is required not to confound them with those of E. camphora, a smaller fruit with valves exserted, or E. acervula.*

**Habitat.**—Coast District (southern half), New South Wales; Victoria.

**REMARKS.**—The systematic position of this species is later dealt with in our paper on Euc., Tas. Roy. Soc., 1912, in addition to remarks given in our Euc. and their Ess. Oils, 1st Edit.



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, New South Wales, in June, 1898. The yield of oil was 0.24 per cent. The crude oil was red in colour, and had a turpentine-like odour. A somewhat large amount of pinene was present, while the higher boiling portion consisted largely of the sesquiterpene. Phellandrene was not detected. Cineol occurs in this oil, although not in large amount. The esters consisted largely of a valeric acid ester and geranyl-acetate. The portion distilling above  $250^{\circ}$  was of a bright blue colour.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9056; rotation  $a_D + 10^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4716, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 18.4.

On rectification 2 per cent. distilled below  $164^{\circ}$  C. (corr.). Between  $164$ – $172^{\circ}$ , 47 per cent. distilled; between  $172$ – $250^{\circ}$ , 34 per cent. came over, and between  $250$ – $265^{\circ}$ , 12 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8872; rotation  $a_D + 17.0^{\circ}$ .

Second " " " " = 0.9002; rotation  $a_D + 6.8^{\circ}$ .

Third " " " " = 0.9355; rotation not taken.

The cineol, determined by the phosphoric acid method in the second fraction, indicated 23 per cent. in the crude oil (O.M.).

Another sample of the oil of this species was obtained from Barber's Creek in May, 1898. This oil agreed with the above sample except that the yield was less, but in ester content, rotations for the several fractions and other physical characters, as well as in the amount of cineol present, the oils were practically identical.

The first sample of oil had been kept in the dark, and in September, 1919, was again analysed. Very little alteration had taken place in the oil during the 21 years it had been stored, except that the specific gravity had increased a little. On distillation 80 per cent. came over boiling below  $190^{\circ}$  C. The crude oil and fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9192; rotation not taken; refractive index at  $20^{\circ}$  = 1.4724.

Fraction " " " " = 0.8964; rotation  $a_D + 13^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4658.

The cineol was determined by the resorcinol method in the portion distilling below  $190^{\circ}$ ; when calculated for the crude oil the result was 42 per cent. By the rapid phosphoric acid method it was 26 per cent. when calculated for the crude oil.

## 40. *Eucalyptus Baeuerleni*.

(F.v.M., in Vic. Nat. October, 1890, p. 76.)

**Brown Gum.**

**Systematic.**—A tree only known, so far, from the Sugar Loaf Mountain, Clyde-road, between Nelligen and Braidwood, occurring there on the very rocky declivities at an altitude from 2,000–4,000 feet; attaining at the lowest level a diameter of 2 feet and a height from 40 to 60 feet, while at the highest elevation (4,000 feet) it grows shrubby or in "mallee" form 4 to 10 feet high, flowering profusely. It has a habit of growing in clusters of perhaps four to eight



small-sized trees, springing from an enormous bulging and spreading stock, irregular in shape, of a diameter from 4 to 10 feet or more. On the lower levels the larger trees grow straight, with a smooth, light brown and very thin bark; smooth within 1 or 2 feet of the ground. Leaves somewhat shining and of the same appearance on both sides, the umbels regularly three-flowered. Calyx angular, sessile; operculum much constricted, rostrate, angular.

**Fruit.**—Inclined to be hemispherical in shape, occasionally ribbed; rim broad, outer edge recurved; valves prominent, and exserted; under  $\frac{1}{2}$  inch in diameter.



*It is probably only a depauperate form of E. globulus.*

**Habitat.**—Sugar Loaf Mountain, Braidwood, N.S.W.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, New South Wales, in August, 1898. The yield of oil was 0.33 per cent. The crude oil was but little coloured, and had an odour resembling the crude pinene-cineol Eucalyptus oils generally. It contained no phellandrene, but pinene and cineol were both present. Eudesmol was detected by crystallisation. The third fraction consisted largely of the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.8895, rotation  $a_D + 4.05^\circ$ ; refractive index at 20° = 1.4784, and was soluble in 4 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 9.98.

On rectification 2 per cent. distilled below 170° C. (corr.). Between 170–183°, 78 per cent. distilled; between 183–240°, 11 per cent. came over, and between 240–280°, 7 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8789; rotation  $a_D + 4.25^\circ$ .

Second " " " " = 0.8835; " "  $a_D + 0.8^\circ$ .

Third " " " " = 0.9432; " " not taken.

The cineol, determined by the phosphoric acid method in the large fraction was 24 per cent., indicating about 20 per cent. in the original oil (O.M.).

## 41. *Eucalyptus viminalis*, var. A.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, 1st. Edit., 1902, p. 91.)

**Systematic.**—A tree apparently similar in most morphological characters to the type.

**Fruit.**—The fruits, however, are less pedicellate, often sessile, and not quite hemispherical, nor are the valves quite so exserted, nor the mouth of the capsule so expanded as in the type. The fruits in dried specimens are almost invariably affected with a fungoid growth on the inner surface of the valves.



**Habitat.**—Crookwell District, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Laggan, near Crookwell, New South Wales, in May, 1901. The yield of oil was 0.7 per cent. The crude oil was amber-coloured, and had an almond-like odour, indicating the probable presence of benzaldehyde. This odour appears to be characteristic of the oil of this species, and has not, so far, been detected in any other *Eucalyptus* oil. It was first noticed in a sample of oil presented by Mr. J. J. Hook to the Goulburn Museum.

In April, 1901, a commercial sample of freshly-distilled oil from this species was submitted to us for determination. It was found to be identical in composition with the specimen in the Goulburn Museum.

The oil of this species was rich in cineol; it contained pinene, but phellandrene was absent. On agitating a portion of the oil with acid sodium sulphite a small amount of a crystalline compound was obtained; this was separated, purified, decomposed, and the aldehyde removed by ether. The product had a marked odour of benzaldehyde, but an attempt to oxidise it to benzoic acid was not successful, so that its identity yet remains to be proved.

The crude oil from the Laggan material had specific gravity at 15° C. = 0.9122; rotation  $a_D + 6.7^\circ$ ; refractive index at 20° = 1.4654, and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.6.

On rectification, 2 per cent. distilled below 162° C. (corr.). Between 162–180°, 83 per cent. distilled; between 180–188°, 6 per cent. came over, and between 188–250°, 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9083; rotation  $a_D + 8.2^\circ$ .

Second       "       "       "       " = 0.9216;       "       not taken.

Third       "       "       "       " = 0.9281;       "       "

The cineol, determined by the phosphoric acid method in the first fraction, was 55 per cent. (O.M.), indicating about 48 per cent. in the crude oil.

The third fraction consisted largely of the sesquiterpene.

The above sample was stored in the dark, and in November, 1919, again analysed. Not much alteration had taken place during the time it had been kept, with the exception that the specific gravity had increased a little. The rotation had also altered, and showed a slightly higher dextro-rotation, evidently due to the diminution in rotation of a lævo-rotatory constituent. The odour of benzaldehyde was very pronounced in the rectified oil, particularly after the cineol had been fixed by phosphoric acid. 87 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9192; rotation  $a_D + 7.8^\circ$ ; refractive index at 20° = 1.4664.

Rectified portion       "       "       " = 0.9113; rotation  $a_D + 9.4^\circ$ ; refractive index at 20° = 1.4607.

The cineol was determined by the resorcinol method in the rectified portion; the result was 63 per cent. when calculated for the crude oil. By the rapid phosphoric acid method it was 58 per cent.

In the year 1908, Mr. W. T. Farrell, of the Australian *Eucalyptus* Oil Co., submitted a sample of *Eucalyptus* oil he was distilling for commercial purposes from a tree known in the South Coast district of New South Wales as "Ribbon Gum." This oil indicated the presence of benzaldehyde, and in other respects, particularly the botanical material, agreed with the species we had previously



received from Laggan, near Crookwell, New South Wales. It was thought desirable, therefore, to obtain material for distillation.

Through the kindness of Mr. Farrell leaves and terminal branchlets for distillation were received from Monga, New South Wales, in June, 1910.

The yield of oil was 0.9 per cent. The crude oil was of a dark orange-brown colour, due to the action of the phenols on the iron removed from the still in the process of distillation. It contained much cineol, and dextro-rotatory pinene was also present in some quantity; but phellandrene was absent. The aldehydes were pronounced, benzaldehyde being detected by the odour.

A portion of the oil was agitated with dilute soda solution until the phenols were absorbed; the alkaline solution was separated, washed with ether, acidified, and the phenols prepared in the ordinary way. The amount of phenols in the crude oil was thus shown to be 0.46 per cent.; tasmanol was readily detected by the characteristic reaction with ferric chloride, although the principal phenol was australol.

The crude oil from which the phenols had been removed had specific gravity at  $15^{\circ}\text{C.} = 0.9141$ ; rotation  $a_D + 6.2^{\circ}$ ; refractive index at  $20^{\circ} = 1.4655$ , and was soluble in 1.6 volumes 70 per cent. alcohol. The saponification number for the esters was 3.4.

On rectification, 1 per cent. distilled below  $168^{\circ}\text{C. (corr.)}$ . Between  $168\text{--}172^{\circ}$ , 20 per cent. distilled; between  $172\text{--}193^{\circ}$ , 62 per cent. came over, and between  $193\text{--}204^{\circ}$ , 6 per cent. distilled, leaving 11 per cent. as residue. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9044$ ; rotation  $a_D + 10^{\circ}$ ; refractive index at  $20^{\circ} = 1.4612$ .

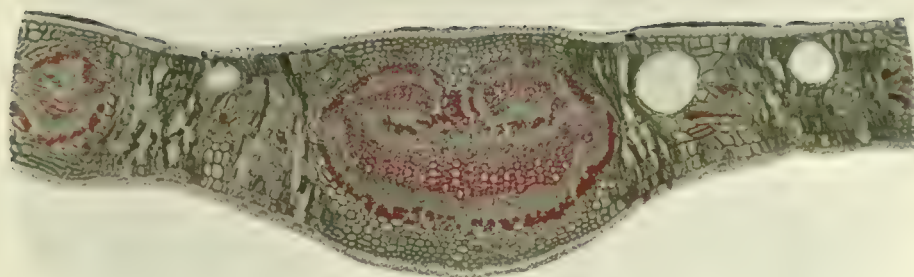
Second     ,,             ,,             ,,     = 0.9094; rotation  $a_D + 7.1^{\circ}$ ; refractive index at  $20^{\circ} = 1.4614$ .

Third       ,,             ,,             ,,     = 0.9208; rotation  $a_D + 2.2^{\circ}$ ; refractive index at  $20^{\circ} = 1.4691$ .

The saponification number for the first fraction was only 1.8, while that in the residue was 7.6 by boiling, and 7.1 in the cold with two hours' contact. The indication was that the principal ester was geranyl-acetate.

The cineol was determined by the resorcinol method in the portion distilling below  $193^{\circ}$ . When calculated for the crude oil the result was 60 per cent.



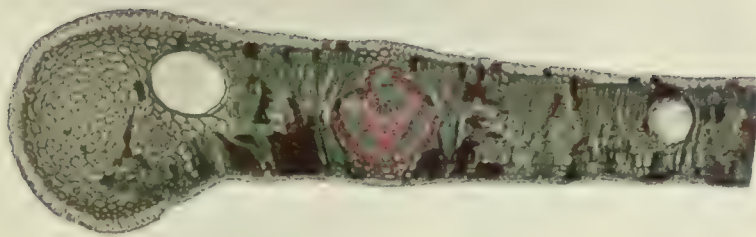


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Section through the mid-rib of the leaf and dependent tissue. Three oil glands are sectioned, two on the right and all are well below the thickened cuticle. The supporting tissue to all the bundles sectioned is a feature of the plate; the palisade tissue extends from the two surfaces of the leaf, but is apparently more developed towards the upper side.

**EUCALYPTUS PANICULATA, SM.**





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Cross section showing the thickened edge of a leaf blade with an oil gland in the vicinity, and another at the right of the section. The cuticle in this case is strongly developed on the upper surface and around the edge, where it is backed by a mass of supporting tissue. The palisade parenchyma is strongly developed on the upper surface. The dark-coloured patches probably indicate tannin in the tissue.

× 55.

*EUCALYPTUS PANICULATA*. SM.





## 42. *Eucalyptus paniculata*.

(Sm., in Trans. Linn. Soc., III, 287.)

White Ironbark.

**Systematic.**—Often a tall tree. Bark hard, compact, furrowed. Abnormal leaves broadly lanceolate, up to 7 inches long, up to 2 inches broad, pale on the under side; venation indistinct, lateral veins spreading, intramarginal vein slightly removed from the edge. Normal leaves lanceolate, generally under 6 inches long, and about 1 inch broad, under surface sometimes pale-coloured; venation distinct, but occasionally submerged in the leaf tissue, lateral veins spreading, not very oblique, intramarginal vein removed from the edge. Flowers in axillary or terminal panicles, from six to ten in each umbel. Calyx under 3 lines in diameter on a pedicel of about the same length; operculum conical, but generally constricted at its base.

**Fruit.**—Urn-shaped, pyriform, or inclined to hemispherical; rim flat; valves inserted or slightly exserted; varies in length from 3 to 4 lines and under 3 lines in diameter, slightly less in some forms.



*The fruits are not easily confounded with those of any other species, except perhaps E. intertexta or E. fasciculosa. Some forms have a half-round ring below the outer edge and valves deeply inserted, whilst at other times the valves are exserted.*



**Habitat.**—Coast district and Dividing Range of New South Wales, Victoria and Queensland.

**REMARKS.**—The systematic position of this species seems now firmly established, as, owing to the morphological resemblances in herbarium material, it has in the past been confounded with other species, especially *E. fasciculosa*. The common names are unfortunate, indicating extremes of colour, whereas such do not hold. The wood at first in all cases is whitish, and changes on exposure to a grey or at Port Macquarie with dark lines, hence its name. "Black Ironbark" in that district. The bark is deeply furrowed, hard and of a corky nature, generally with less kino than obtains in other "Ironbarks." It is a slow grower, but a foliaceous tree.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, New South Wales, in October, 1900. The yield of oil was 0.1 per cent. The crude oil was olive-brown in colour, and had a somewhat aromatic odour. It contained much pinene, also some cineol, but phellandrene could not be detected. The oil contained some free alcohol, to which the aromatic odour was largely due.

The crude oil had specific gravity at 15° C. = 0.901; rotation  $\alpha_D + 7.8^\circ$ ; refractive index at 20° = 1.4744, and was soluble in 1 volume 80 per cent. alcohol.

The saponification number for the esters and free acid as 7.11. A portion of the oil was acetylated by boiling with acetic anhydride and sodium acetate in the usual way. The saponification number of the acetylated oil was 56.14, indicating the presence of a fair amount of alcoholic bodies. It is probable that the principal alcohol is not geraniol, but its identity remains to be determined. It will probably be found to be terpineol.

On rectification a rather large amount of acid water and volatile aldehydes came over below  $158^{\circ}$  C. (corr.). Between  $158-172^{\circ}$ , 53 per cent. distilled; between  $172-183^{\circ}$ , 27 per cent. came over; between  $183-227^{\circ}$ , only 5 per cent. distilled, and between  $227-260^{\circ}$ , 6 per cent. distilled. These fractions gave the following:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8893; rotation  $a_D + 9.7^{\circ}$ .

Second       "       "       "       " = 0.9059;       "       "       " +  $1.3^{\circ}$ .

Third       "       "       "       " = 0.9084;       "       "       " —  $2.9^{\circ}$ .

The cineol determined by the phosphoric acid method was 29 per cent. (O.M.). The higher boiling portion consisted largely of the sesquiterpene.

### 43. *Eucalyptus cornuta*.

(Labill., Voy. I, 403, t. 20, 1799.)

Yate Gum.

**Systematic.**—A tree of moderate size with a smooth bark on the upper branches, but dark and rugged lower down, approaching that of an "Ironbark." Abnormal leaves orbicular or ovate. Normal leaves lanceolate, or ovate-lanceolate, thick, usually under 4 inches long; venation not prominent, intramarginal vein somewhat removed from the edge, lateral veins moderately oblique. Flowers six to twelve not immersed in the receptacle; sessile on an axillary peduncle. Calyx tube oblong, turbinate; operculum about  $1\frac{1}{4}$  inch long, tapering to the end, obtuse.

**Fruit.**—Closely crowded in a cluster at the head of peduncle, bell-shaped, sessile or shortly pedicellate; rim narrow, surmounted by the valves, which connive and form a very conspicuous dome; 4 lines in length, exclusive of the much exerted valves.

*At first appearance they show a resemblance to those of E. Lehmanni, but are quite separate and distinct from each other, and do not coalesce as in that species, nor are they immersed in the receptacle as obtains in E. Lehmanni. The two species have been confused by some systematists.*



**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—The oil of this species was distilled by Mr. P. R. H. St. John, at Melbourne, in September, 1919, from cultivated trees in the Botanic Gardens of that city. The yield of oil he obtained was 1.2 per cent. The crude oil was light in colour and contained a large proportion of volatile aldehydes, principally valeraldehyde. The constituents present were dextro-rotatory pinene, cineol, amyl alcohol, a butyric acid ester, higher boiling alcohols, and a little sesquiterpene. Phellandrene was absent.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9043, rotation  $a_D + 10.1^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4601, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 25.4, and in the cold



with two hours' contact 14.8. After acetylation the number was 73.7, and in the cold 59. The indication is thus for a considerable amount of alcoholic bodies, but these are so mixed, that the molecular value cannot be stated. The aldehyde absorption was 8 per cent.

On rectification, no less than  $8\frac{1}{2}$  per cent. distilled below  $153^{\circ}$  C. (corr.). Between  $153$ – $171^{\circ}$ , 18 per cent. distilled; between  $171$ – $193^{\circ}$ , 63 per cent. came over, and between  $191$ – $214^{\circ}$ , 8 per cent. These fractions gave the following results:—

|                 |                              |                                                                            |         |
|-----------------|------------------------------|----------------------------------------------------------------------------|---------|
| First fraction, | sp. gr. at $15^{\circ}$ C. = | 0.8342; rotation $a_D + 9.4^{\circ}$ ; refractive index at $20^{\circ}$ =  | 1.4158. |
| Second          | „ „ „ =                      | 0.8876; rotation $a_D + 15.6^{\circ}$ ; refractive index at $20^{\circ}$ = | 1.4580. |
| Third           | „ „ „ =                      | 0.9077; rotation $a_D + 9.5^{\circ}$ ; refractive index at $20^{\circ}$ =  | 1.4639. |
| Fourth          | „ „ „ =                      | 0.9248; rotation $a_D + 2.1^{\circ}$ ; refractive index at $20^{\circ}$ =  | 1.4678. |

The cineol was determined by the resorcinol method in the portion distilling between  $153$ – $193^{\circ}$ ; the result calculated for the original oil was 57 per cent. By the phosphoric acid method the cineol was 31 per cent., thus showing a large proportion absorbed by resorcinol other than cineol.

In the endeavour to locate these constituents a portion was separated, boiling between  $151$ – $192^{\circ}$ ; the amount which came over between those temperatures was 83 per cent. This fraction had specific gravity at  $15^{\circ}$  C. = 0.9033; rotation  $a_D + 10.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4628. Saponification number 15.7, and in the cold with two hours' contact it was 13. After acetylating, the number was 42, thus showing that a considerable portion of the alcoholic bodies were high boiling. The cineol determined by the resorcinol method was 67.5 per cent.; and by the phosphoric acid method 40 per cent. by two determinations. The aldehydes by absorption were 6 per cent., and calculating for amyl alcohol, and butyl-butyrate as ester, a considerable portion of the absorbable bodies still remains unaccounted for, thus indicating the presence of an unreactive constituent which is also absorbed by resorcinol.

## 44. *Eucalyptus quadrangulata*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 451, t. XXXIX.)

Grey Box.

**Systematic.**—A tree of 80 to 100 feet and diameter of 2 to 4 feet. Bark very much resembles that of ordinary "Box," *E. hemiphloia*, in general appearance, but is more fuzzy and softer than the latter. The branches have smooth tips. Abnormal leaves narrow-lanceolate, cordate and clasping at the base, strictly opposite, markedly paler on the under surface. The early stems are brown (commonly chocolate-brown), and usually square in section and winged. Normal leaves (branchlets angular), lanceolate or narrow-lanceolate, slightly falcate, usually 4 to 6 inches long, scarcely paler on the under surface; venation conspicuous on both sides, the intramarginal vein conspicuously removed from the

edge, the lateral veins spreading. Umbels axillary, consisting usually of four to eight sessile flowers in the head; the common stalk being broadish and strongly compressed. The calyces sub-conical and exceeding the operculum, which is conoid, the calyces sometimes angular.

**Fruit.**—Small, shining, bell-shaped; rim medium; valves slightly exserted, and usually three in number; about 2 lines long and 2 lines broad.



*Somewhat resembles those of E. camphora, but not quite so turbinate, and the valves are more exserted and pointed than obtains in that species.*

**Habitat.**—This species has a very limited range, so far as is known at present, having been found only in the neighbourhood of Hill Top, about 70 miles south of Sydney; Milton, and Mittagong, New South Wales.

**REMARKS.**—The sessile fruits and abnormal leaves, as well as the timber and bark, differentiate this species from *E. Bridgesiana*, R.T.B., and *E. Bosistoana*, F.v.M., and *E. conica*, D. & M., its nearest affinities. The timber is pale-coloured, hard, and one of the best "White Box" timbers of New South Wales. Unfortunately, as stated above, its distribution is limited.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Milton, New South Wales, in February, 1900. The yield of oil was 0.68 per cent. The crude oil was reddish-brown in colour, and had an odour resembling those belonging to the cineol-pinene class of Eucalyptus oils generally. The oil of this species may be considered to consist very largely of dextro-rotatory pinene and cineol. Phellandrene was not present, and the esters small in amount. The sesquiterpene was not at all pronounced.

The crude oil had specific gravity at 15° C. = 0.9064; rotation  $a_D + 10.7^\circ$ ; refractive index at 20° = 1.4625, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.9.

On rectification 2 per cent. distilled below 162° C. (corr.). Between 162–183°, 91 per cent. distilled; and between 183–198°, 3 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9047; rotation  $a_D + 11.6^\circ$ .

Second " " " " = 0.9294; " not taken.

The cineol, determined in the large fraction by the phosphoric acid method, was 35 per cent., indicating about 32 per cent. in the crude oil (O.M.).

The comparative absence of high boiling constituents in the oil of this species is exceptionable for those of this class.

The above sample of oil had been stored in the dark, and in September, 1919, was again analysed. Not much alteration had taken place during the nineteen years it had been kept, except that the cineol had evidently increased in amount. The crude oil and the fraction gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9192; rotation  $a_D + 10.6^\circ$ ; refractive index 20° = 1.4648.

Fraction " " " " = 0.9125; rotation  $a_D + 10.9^\circ$ ; refractive index at 20° = 1.4607.

The cineol was determined by the resorcinol method and calculated for the crude oil; the result was 69 per cent. By the rapid phosphoric acid method it was 54 per cent., when calculated for the crude oil. Terpeneol was detected in the rectified portion,



## 45. *Eucalyptus conica*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 612, t. XLVIII, fig. 1-3.)

### A Box.

**Systematic.**—A tree of medium size, with pendulous branches. Bark of the ordinary "Box" character, persistent right on to the small branches. Abnormal leaves pale green, not glaucous, broadly ovate; the intramarginal vein considerably distant from the margin, and with the midrib giving the leaf a triplinerved appearance. Normal leaves lanceolate, ultimately narrow-lanceolate, 4 inches long by  $\frac{1}{2}$  inch broad, varying, however, in length and width; the intramarginal vein is distinctly removed from the edge of the leaf, although this is less marked in the case of narrow leaves, the venation is oblique, but few of these secondary veins are as prominent as the intramarginal vein. The foliage is drooping, and has frequently long stalks. Buds clavate, the calyx tube greatly exceeding the operculum in size; operculum nearly hemispherical, with a small umbo; the calyx tube tapering gradually to the common point of attachment to the stalk.

**Fruit.**—Narrow, conical (hence the specific name), tapering to the point of attachment of the common stalk; rim thin; the valves, which are three or four and very small, are deeply sunk; the greatest length 3 lines by 2 lines broad.



*Requires care so as not to confound them with E. Fletcheri or perhaps E. crebra.*

**Habitat.**—Found in the country west of the Dividing Range and its spurs, forming, with *E. hemiphloia* and *E. Woollsiana*, the "Box" of the western country, New South Wales.

**REMARKS.**—Since the original description appeared under the Author's names (*loc. cit.*), the species has been lowered to varietal rank by Maiden, "Critical Revision" vol. ii, p. 123, under *E. Baueriana*, Schau., a species founded on leaves and inflorescence only, "in plump bud and expanded flower," J.H.M. *loc. cit.* and of tropical origin, Benth., B.Fl. iii, 214. Such material and description is of no practical value these times. As Deane and Maiden accurately describe this tree from material and known locality, it is thus very clear what *Eucalyptus* is meant, and so we prefer to retain their nomenclature, for then there can be no doubt about the basis upon which the botany and chemistry of this work is founded.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Parkes, New South Wales, in July, 1900. The yield of oil was 0.59 per cent. The crude oil was of an orange-brown colour, and had a pronounced odour of volatile aldehydes. Pinene was present in some quantity, and there was also a fair amount of cineol; but phellandrene was not detected, and esters only in small amount. It may be that aromadendral was present in small quantity. The higher boiling portion contained the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9057; rotation  $\alpha_D + 5.24^\circ$ ; refractive index at 20° = 1.4676, and was soluble in 6 volumes 70 per cent. alcohol. The saponification number was 6.26.



On rectification, 2 per cent. distilled below  $162^{\circ}$  C. (corr.). Between  $162-183^{\circ}$ , 87 per cent. distilled; between  $183-255^{\circ}$ , 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.9029; rotation  $a_D + 5.87^{\circ}$ .

Second " " " = 0.9285; " not taken.

The cineol, determined by the phosphoric acid method in the large fraction, was 40 per cent., indicating about 35 per cent. in the original oil (O.M.).

This sample had been stored in the dark, and in July, 1919, was again analysed, when 84 per cent. distilled below  $190^{\circ}$  C. The crude oil and the fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9561; rotation  $a_D + 6.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4705.

Fraction " " = 0.9224; rotation  $a_D + 3.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4613.

The cineol was determined by the resorcinol method in the redistilled portion and calculated for the crude oil; the result was 70 per cent. By the rapid phosphoric acid method it was 48 per cent. when calculated for the crude oil, thus showing the presence of constituents other than cineol, which were absorbed by the resorcinol. Terpeneol was detected in the rectified portion.

## 46. *Eucalyptus Bosistoana*.

(F.v.M., in the Australian Journ. Phar., Oct., 1895.)

### Ribbon Box.

**Systematic.**—This tree was the *Eucalyptus* described by Baron von Mueller (1895), and has, therefore, only quite recently been botanically placed. Its other vernacular name is "Grey Box Tree" (Mueller). It is a tall tree, running up to over 150 feet in height, and 3 to 4 feet in diameter, with a symmetrically shaped head. Bark rough on the trunk at the base, but smooth towards and on the branches, and stained in places with kino exudations. Leaves variable in shape, on the younger trees broad to lanceolate, of the same colour on both sides, often oblique, the intramarginal vein removed from the edge; in mature trees the leaves are much narrower and more acuminate, lateral veins fairly distinct and oblique, petiole rather long and slender. Umbels axillary or terminal, few buds in the heads. Young buds somewhat like those of *E. pilularis*; operculum semi-ovate, hemispheric, often distinctly pointed.

**Fruit.**—Pilular; rim truncate; cells numerous; valves not exserted; about  $\frac{1}{4}$  inch in diameter.

*The fruits are characteristic and easily distinguish the species, having more cells than obtains in almost any other species.*



**Habitat.**—Cabramatta, Camden and along the coast of N.S.W. to Victoria, extending to South Australia.

**REMARKS.**—Dedicated to *Joseph Bosisto*, C.M.G., who investigated many of the products of the Eucalypts, especially their essential oils. The name "Red Box" has recently been given to it, but it is difficult to understand how it can apply, as the timber is quite pale, being yellowish-white to yellowish-pink; it is a beautiful timber for working, having a close grain, and much resembles English Box. It is very durable, both in the ground and for bridge decking, and altogether is a tree worthy of cultivation.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, New South Wales, in August, 1898. The yield of oil was 0.97 per cent. The crude oil was orange-brown in colour, and had an odour resembling those of the cineol-pinene class of Eucalyptus oils generally. Pinene was the principal terpene, and cineol was present in some quantity, but phellandrene was absent, and the esters quite small in amount. Terpeneol was detected. The volatile aldehydes were pronounced. The fourth fraction consisted largely of the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9078; rotation  $a_D + 9.26^\circ$ ; refractive index at 20° = 1.4675, and was soluble in 5 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.2.

On rectification, 2 per cent. distilled below 167° C. (corr.). Between 167–172°, 41 per cent. distilled; between 172–183°, 40 per cent. came over; between 183–250°, 8 per cent. distilled, and between 250–265°, 3 per cent. distilled. These fractions gave the following results:—

|                 |                             |                               |
|-----------------|-----------------------------|-------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8981; | rotation $a_D + 13.4^\circ$ . |
| Second          | " " " = 0.9096;             | " " + 7.37°.                  |
| Third           | " " " = 0.9189;             | " " not taken.                |
| Fourth          | " " " = 0.9376;             | " " "                         |

The cineol, determined by the phosphoric acid method in the portion boiling below 183°, was 43 per cent. (O.M.); indicating about 35 per cent. in the crude oil at time of distillation.

The above sample had been stored in the dark, and in August, 1919, was again analysed. 84 per cent. distilled below 190° C. There was an apparent increase in the cineol content, as is indicated by the physical properties as well as by the quantitative determinations. The crude oil and the fraction gave the following results:—

|            |                             |                              |                                   |
|------------|-----------------------------|------------------------------|-----------------------------------|
| Crude oil, | sp. gr. at 15° C. = 0.9302; | rotation $a_D + 9.4^\circ$ ; | refractive index at 20° = 1.4679. |
| Fraction   | " " " = 0.9134;             | rotation $a_D + 9.0^\circ$ ; | refractive index at 20° = 1.4633. |

The cineol was determined by the resorcinol method in the fraction and calculated for the crude oil; the result was 63 per cent. A determination by the rapid phosphoric acid method on the fraction and calculated for the crude oil gave 58 per cent. of cineol. The difference was largely due to the terpeneol.

## GROUP III.

## CLASS (a).

In this Group are placed the following EUCALYPTS yielding an oil consisting principally of cineol and pinene, in which the cineol exceeds 40 per cent. at the time of distillation, but under 55 per cent. Phellandrene is absent, and aromadendral\* very rarely occurs.

- |     |                   |                                       |
|-----|-------------------|---------------------------------------|
| 47. | <i>Eucalyptus</i> | <i>polyanthemos.</i>                  |
| 48. | <i>E.</i>         | <i>Stuartiana.</i>                    |
| 49. | <i>E.</i>         | do var. <i>cordata.</i>               |
| 50. | <i>E.</i>         | <i>bicolor.</i>                       |
| 51. | <i>E.</i>         | <i>longifolia.</i>                    |
| 52. | <i>E.</i>         | <i>Behriana.</i>                      |
| 53. | <i>E.</i>         | <i>Rossii.</i>                        |
| 54. | <i>E.</i>         | <i>salmonophloia.</i>                 |
| 55. | <i>E.</i>         | <i>Seeana.</i>                        |
| 56. | <i>E.</i>         | <i>rostrata</i> var. <i>borealis.</i> |
| 57. | <i>E.</i>         | <i>camphora.</i>                      |
| 58. | <i>E.</i>         | <i>Maideni.</i>                       |
| 59. | <i>E.</i>         | <i>Rodwayi.</i>                       |
| 60. | <i>E.</i>         | <i>cinerea.</i>                       |
| 61. | <i>E.</i>         | <i>dealbata.</i>                      |
| 62. | <i>E.</i>         | <i>resinifera.</i>                    |
| 63. | <i>E.</i>         | <i>accedens.</i>                      |
| 64. | <i>E.</i>         | <i>vernica.</i>                       |
| 65. | <i>E.</i>         | <i>urnigera.</i>                      |
| 66. | <i>E.</i>         | <i>unialata.</i>                      |
| 67. | <i>E.</i>         | <i>Gullicki.</i>                      |
| 68. | <i>E.</i>         | <i>platypus.</i>                      |
| 69. | <i>E.</i>         | <i>calycogona.</i>                    |
| 70. | <i>E.</i>         | <i>Dalrympleana.</i>                  |

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\* The name aromadendral is used throughout this work in a general sense to denote the presence of one or more members of this group of characteristic aldehydes, which includes cuminaldehyde and cryptal. See also the article in this work on these aldehydes.



## 47. *Eucalyptus polyanthemos*.

(Schau., in Walp. Rep., ii, 924, 1843.)

**Red Box.**

**Systematic.**—A fair-sized tree, with a persistent "Box" bark right out to the branchlets. Leaves oval, ovate-acuminate or emarginate to lanceolate, the latter form about 3 inches long, and the former generally under 3 inches in diameter, glaucous, thin to almost coriaceous, petiole rather slender, measuring sometimes over 1 inch long; venation strongly marked, intramarginal vein removed from the edge, particularly so in the abnormal leaves, lateral veins oblique, distant. Flowers in terminal or axillary panicles. Calyx under 2 lines, tapering into a short pedicel; operculum hemispherical, shortly acuminate.

**Fruit.**—Hemispherical or pear-shaped on a rather slender pedicel; rim thin, contracted, notched; valves inserted; under 3 lines in diameter.



*Could easily be confused with E. Fletcheri and perhaps E. melanophloia, but less pilular than the latter.*

**Habitat.**—Pambula, Bungendore, Albury; Delegate River, New South Wales; Queensland and Victoria.

**REMARKS.**—This tree is characterised principally by its hard, red timber and persistent "Box" bark. It is very difficult to differentiate herbarium material of this species from that of *E. Fletcheri*, R.T.B., but in the field the two are easily determined. The chemistry of the oils of the two trees also shows them to be dissimilar. *E. ovalifolia*, R.T.B., which is also locally known by the name of "Red Box," is not to be confounded with *E. polyanthemos*, Schau., as it has a smooth white bark and characteristic leaves, which differ from those of *E. polyanthemos* and *E. Fletcheri*. "Slaty Gum," *E. Dawsoni*, R.T.B., is also quite a distinct tree from *E. polyanthemos*, Schau. (*Vide* also chemistry of oils of these species in this work.)

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Bungendore, N.S.W., in July, 1898. The yield of oil was 0.83 per cent. The crude oil was of a light amber colour, and had an odour resembling those of the cineol-pinene class of Eucalyptus oils. It was rich in cineol, contained some pinene, but phellandrene was absent. The oil may be considered a good one for pharmaceutical purposes, although the esters were present in rather large amount. Unfortunately the yield of oil is somewhat small.

The crude oil had specific gravity at 15° C. = 0.9281; rotation  $a_D + 5.4^\circ$ ; refractive index at 20° = 1.4679, and was soluble in  $1\frac{1}{4}$  volumes of 70 per cent. alcohol. The saponification number for the esters and free acid was 20.7.

On rectification, the usual amount of acid water and aldehydes came over below 170° C. (corr.). Between 170–183°, 83 per cent. distilled; between 183–224°, 10 per cent. came over, and between 224–240°, only 2 per cent. distilled, which portion consisted largely of a sesquiterpene. These fractions gave the following:—

First fraction, sp. gr. at 15° C. = 0.9182; rotation  $a_D + 5.1^\circ$ .

Second " " " " = 0.9282; " " + 2.5°.

The cineol determined by the phosphoric acid method in the large fraction was 65 per cent., or about 54 per cent. in the crude oil (O.M.).

The above sample of oil was stored in the dark, and in August, 1919, was again analysed. But little alteration had taken place in the oil during the twenty-one years it had been kept, although the specific gravity had slightly increased, perhaps the cineol had increased a little also, judging from the results with the large fraction.

On rectification, 90 per cent. of the oil distilled below  $190^{\circ}$  C. The results obtained were as follows:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9382; rotation  $a_D + 5.0^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4672.

Large fraction „ „ = 0.9211; rotation  $a_D + 4.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4601.

The cineol was determined by the resorcinol method in the portion boiling below  $190^{\circ}$ ; when calculated for the crude oil, the result was 81 per cent. By the phosphoric acid method it was 65 per cent., so that absorbable substances, other than cineol and alcohols, were present in some quantity. This is shown by the results after acetylation, as the saponification number was then only 20.6.

## 48. *Eucalyptus Stuartiana*.

(F.v.M., in B.Fl., iii, 243.)

**Apple of Victoria.**

**Systematic.**—A large tree, with a red, stringy bark, and a reddish-coloured, worthless timber, similar to that of *E. cinerea*, F.v.M., and with glaucous, terete branchlets, and glaucous inflorescence. Abnormal leaves glaucous, ovate acuminate, cordate, sessile, opposite, rarely lanceolate, variable in size, the larger ones about 6 inches long and 4 inches wide, and having a very pronounced venation, the marginal vein being removed from the edge; the smaller leaves are much finer in texture. Leaves of mature trees lanceolate, generally under 6 inches long, and varying in breadth, occasionally opposite, same colour on both sides; venation distinct, lateral veins oblique, spreading, intramarginal one removed from the edge. Peduncles axillary, flattened, about 3 lines long, with generally seven or more almost sessile flowers in the head. Calyx tube conical, under 2 lines in diameter; operculum conical, acute, slightly depressed below the apex, or hemispherical and acuminate.

**Fruit.**—Sessile, turbinate, bell-shaped to hemispherical, occasionally angular at the base; rim thick; valves exerted, sometimes prominently so, when they are acute; about 3 lines in diameter.



*These fruits have often a strong resemblance to E. viminalis, but rather smaller.*

**Habitat.**—This is quite a Victorian species, occurring more particularly at Black Flat, Oakleigh, Ringwood.



**REMARKS.**—This is a good species, and quite distinct from "Argyle Apple" (*E. cinerea*, F.v.M.), which has a similar bark and timber and which characteristics often led Baron von Mueller to express a doubt whether the two trees were not one and the same species (*vide* "Eucalyptographia" under *E. pulverulenta*). The two differ distinctly in foliage and fruits. It has little or no affinity with *E. Bridgesiana*, which tree has a pale-coloured timber, and a "Box" bark and hemispherical fruits. This latter species was, by Baron von Mueller, working on herbarium material, confounded with the "Victorian Apple" (*E. Stuartiana*), but his frequent reference to the stringy-bark and red-coloured timber of "Argyle Apple" (*E. cinerea*) shows conclusively that *E. Bridgesiana* could hardly have been known to him in the field. A. W. Howitt's *E. pulverulenta*, var. *lanceolata*, we regard as an aberrant form of *E. Stuartiana*, in which the lanceolate form of leaf is less predominant although cordate leaves also occur on mature trees along with flowers and fruits in the axils. The timber, bark, and inflorescence are almost identical with the type *E. Stuartiana*. It has little connection with the lanceolate form of the "Argyle Apple" (*E. cinerea* F.v.M.) of New South Wales, as that species has consistently three flowers in the axils, whilst Howitt's tree has almost uniformly seven—a fact that appears to have been overlooked by those who have synonymised it with the "Argyle Apple" (*E. cinerea*, F.v.M.). Dr. Howitt who knew both trees well in the field, and discussed them with the late Baron von Mueller, was in accord with us in our classification of *E. Stuartiana* and *E. Bridgesiana*.

**ESSENTIAL OIL.**—We are indebted to Dr. A. W. Howitt, F.G.S., for the material of this species for distillation.

The leaves and terminal branchlets had been collected as for commercial distillation, and were sent from Melbourne, Victoria, in April, 1898. The yield of oil was 0.4 per cent. The crude oil was red in colour, and had an odour resembling the cineol-pinene oils generally. Phellandrene could not be detected, but pinene was present. The amount of ester was somewhat large, resembling in this respect the oils obtained from *E. cinerea* and allied species. The oil was rich in cineol, and a determination by the phosphoric acid method (O.M.) gave 53 per cent. of that constituent in the crude oil. The specific gravity of the crude oil = 0.916; and optical rotation  $\alpha_D + 4.8^\circ$ ; refractive index at  $20^\circ = 1.4652$ . The saponification number for the esters and free acid was 14.2. The crude oil was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol.

## 49. *Eucalyptus Stuartiana*, var. *cordata*.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, 1st Edit., 1902.)

(Syn. *E. pulverulenta*, var. *lanceolata*, A.W.H.)

**Systematic.**—A small tree, 40 to 50 feet high, with a red, stringy bark. Leaves glaucous, opposite, sessile, cordate to ovate, or alternate, ovate-lanceolate, lanceolate, 3 to 4 inches long, 1 to 2 inches wide; venation well marked, lateral veins oblique, spreading, intramarginal vein well removed from the edge in the ovate leaves. Peduncles axillary, terete, 6 lines long, with from five to eight flowers in the umbel. Calyx conical; operculum hemispherical, acuminate.

**Fruit.**—Sessile, top-shaped; rim thick, convex; valves slightly exserted; 3 lines in diameter.

**Habitat.**—Ovens district, Moe, and many other localities in Victoria.



**REMARKS.**—This tree was first recorded under the above synonym in A.A.A.S., 1898, p. 517, by Dr. A. W. Howitt, to whom we are indebted for the herbarium material. The number of flowers in the umbel and the predominance of lanceolate leaves connect it, in our opinion, more closely with the "Apple," *E. Stuartiana*, F.v.M., of Victoria, than the "Argyle Apple," *E. cinerea*, F.v.M., of New South Wales, which has consistently 3-flowered peduncles and only rarely lanceolate leaves. *E. pulverulenta* is quite a different tree from any of the above, and has no affinity with Dr. Howitt's variety. Mueller's confounding *E. cinerea* with *E. pulverulenta* probably misled Dr. Howitt.



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation of this Victorian tree were received from Dr. A. W. Howitt, F.G.S., in May, 1898. The yield of oil was 1.13 per cent. It scarcely differed in composition from the oil obtained from *E. Stuartiana*, although the esters were more pronounced; it was a little less rich in cineol than the oil of that species. The specific gravity of the crude oil = 0.934, this high specific gravity being due to an excess of high-boiling constituents. The saponification number for the esters and free acid was 35.2. The oil was soluble in 1½ volumes 70 per cent. alcohol.

## 50. *Eucalyptus bicolor*.

(A. Cunn., Hook., in Mitch. Trop. Austr. 390. Syn. *E. pendula*, A. Cunn., in Steud. Nom. Bot., Ed. 2; *E. largiflorens*, F.v.M., in Trans. Vict. Inst., i, 34, and Fragm., ii, 58).

Red Box.

**Systematic.**—A tree in favourable situations attaining a height of 100 feet, and vernacularly known as "Goborro" in some parts of the State. Bark persistent, ashy grey or blackish. Branches more or less drooping, sometimes as much as those of the Weeping Willow. Leaves lanceolate, elliptical, shortly acuminate, of a rather thick texture, silvery grey on both sides, petioles not long; veins few, not distinct, the intramarginal one well removed from the edge. Flowers small, sometimes red, in axillary or terminal panicles, almost sessile; operculum hemispherical.

**Fruit.**—Somewhat pilular in shape, the orifice contracted; the rim narrow; valves enclosed; mostly under 3 lines in diameter.



*Care is required not to mistake the fruits for those of E. polybractea or E. Beyeri, but they are not so tapering as in the latter.*

**Habitat.**—From the Bogan to the Lachlan and Murrumbidgee, New South Wales; South Australia; Victoria; Queensland; North Australia.

**REMARKS.**—This *Eucalyptus* has several vernacular names other than the above, but "Red Box" is the most general one, as it expresses the colour of the timber, which is hard, interlocked, and very durable. The venation of the leaf is very characteristic, and is constant throughout the range of the species, and this feature alone at once differentiates it from *E. intertexta*, R.T.B., and *E. Woollsiana*, R.T.B., which are generally found interspersed with it. In the first edition of this work, these specific data were given under the name *E. pendula*, A. Cunn., but research has since shown that *E. bicolor* is the more correct name for the tree occurring in the districts travelled by this botanist and explorer when he states "the marginal vein is not so close to the edge of the leaf." This marked distance of the marginal vein from the edge of the leaf is quite its specific character amongst *Eucalyptus* species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nyngan, N.S.W., in November, 1899. The yield of oil was 0.85 per cent. The crude oil was light orange-brown in colour, and had a strong odour of volatile aldehydes. In general characters it resembled the oils of the cineol-pinene class of *Eucalyptus* oils; cineol was present in quantity, pinene was the chief terpene, and phellandrene absent. This oil increased in cineol content on keeping.

The leaves of this sample were broader than was the case with other trees of this species growing in this locality, but the oils from both forms were practically identical; the constituents were the same, and these were present in similar proportions.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9155; rotation  $a_D + 5.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4675, and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.4.

On rectification, about 1 per cent. distilled below  $167^{\circ}$  C. (corr.). Between  $167$ – $183^{\circ}$ , 85 per cent. distilled; between  $183$ – $250^{\circ}$ , 3 per cent. came over, and between  $250$ – $260^{\circ}$ , 4 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.9120; rotation  $a_D + 6.5^{\circ}$ .

Second     "     "     "     = 0.9256;     "     not taken.

Third       "     "     "     = 0.9265;     "     not taken.

The cineol, determined by the phosphoric acid method in the fractionated oil, was 55 per cent. (O.M.), indicating about 48 per cent. in the crude oil.

The above sample of oil had been preserved in the dark, and in September, 1919, was again analysed. The increase in the specific gravity during the twenty years it had been kept was distinctly shown, and an increase in cineol was also evident.

On rectification, 78 per cent. distilled below  $190^{\circ}$  C. The results with the crude and rectified oils were as follow :—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9609; rotation  $a_D + 5.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4692.

Fraction     "     "     "     = 0.9316; rotation  $a_D + 4.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4585.

The cineol, determined by the resorcinol method in the portion distilling below  $190^{\circ}$ , and calculated for the crude oil, was 74 per cent. By the phosphoric acid Pharmacopœia method, the cineol in the fraction was 80 per cent., or about 62 per cent. when calculated for the original oil.

## 51. *Eucalyptus longifolia*.

(Link & Otto, Ic. Pl. Sel., 97, t. 45.)

(Syn. *E. Woollsii*, F.v.M.)

**Woollybutt.**

**Systematic.**—Often a tall tree, with a persistent grey, fibrous bark. Leaves lanceolate, often measuring 12 inches in length (some Eucalypts have longer leaves than this species), not shining; venation well marked, intramarginal vein rather close to the edge. Peduncles axillary,  $1\frac{1}{2}$  inch long, mostly bearing three comparatively large flowers. Calyx 5 to 6 lines long, turbinate, often angular.

**Fruit.**—Large, occasionally angular; valves scarcely exerted, very distinct and erect, edge sharp; rim broad, sloping outwards, or bevelled;  $\frac{3}{4}$  inch in diameter. These large fruits, which occur in threes, make the species easy of determination both in the field and herbarium.

*One of the most distinctive capsules of the genus and readily identified.*

**Habitat.**—Port Jackson, New South Wales, to Victoria.

**REMARKS.**—"Woollybutt" appears to be the general vernacular name for this tree, though in the south-east corner of the Continent it is sometimes known as "Peppermint," but it is difficult to understand why it is so called, as the oil contains no peppermint constituent. It is a beautiful foliaceous tree, individual leaves sometimes measuring over a foot long, but the leaves of several other species far exceed this measurement, so that the species name is not happily chosen. The bark is similar to that of some "Box" trees, the upper branches being smooth. The timber is reddish in colour, hard, and very durable.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Canterbury, N.S.W., in August, 1897. The yield of oil was 0.54 per cent. The crude oil was of a light orange-brown colour, and had an odour resembling those of the cineol-pinene Eucalyptus oils generally. It was rich in cineol, contained a little pinene, but phellandrene was absent. The third fraction consisted largely of the sesquiterpene, and as this fraction was rather large, the specific gravity of the crude oil was somewhat high.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9226; rotation  $a_D + 2.86^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4681, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.6.

On rectification, 2 per cent. distilled below  $172^{\circ}$  C. (corr.). Between  $172-183^{\circ}$ , 69 per cent. distilled; between  $183-250^{\circ}$ , 14 per cent. came over, and between  $250-273^{\circ}$ , 10 per cent. distilled. These fractions gave the following results:—

|                 |                                      |                                |
|-----------------|--------------------------------------|--------------------------------|
| First fraction, | sp. gr. at $15^{\circ}$ C. = 0.9158; | rotation $a_D + 3.9^{\circ}$ . |
| Second          | " " " = 0.9240;                      | " not taken.                   |
| Third           | " " " = 0.9460;                      | " not taken.                   |

The cineol, determined by the phosphoric acid method in the first fraction, was 63 per cent. (O.M.), indicating about 45 per cent. in the crude oil.





The above sample had been stored in the dark, and in August, 1919, was again analysed. Not much alteration had taken place during the twenty-two years it had been kept, although the cineol had increased somewhat. 82 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9258; rotation  $a_D + 1.2^\circ$ ; refractive index at 20° = 1.4675.

Redistilled portion „ = 0.9180; rotation  $a_D + 3.6^\circ$ ; refractive index at 20° = 1.4612.

The cineol was determined by the resorcinol method in the rectified portion, and calculated for the crude oil; the result was 71 per cent. By the rapid phosphoric acid method, it was 61 per cent. when calculated for the crude oil.

## 52. *Eucalyptus Behriana*.

(F.v.M., in Trans. Vict. Inst., i, 34, 1854.)

**Systematic.**—A small tree of the “Mallee” country. Branchlets terete. Bark thin, smooth, greenish, hard. Leaves ovate, ovate-lanceolate, oval, acuminate, or shortly acuminate, smooth, coriaceous, more or less shining, 2 to 3 inches long; venation fairly prominent, lateral veins very oblique, distant, spreading, intramarginal vein removed from the edge. Flowers in rather lengthened, terminal panicles. Peduncles short, 3 to 4 lines long, angled; seven or fewer flowers on the umbel. Flowers sessile, calyx angular, almost cylindrical, under 2 lines long; inner operculum hemispherical, shortly acuminate, outer one very small, membraneous and persistent.

**Fruit.**—Small, shining, top-shaped, slightly hemispherical, truncate; rim comparatively thick, sunk; valves enclosed; under 2 lines in diameter.

*In shape they resemble E. odorata, but are much smaller and shining.*

**Habitat.**—Interior of New South Wales; South Australia; Victoria.



**REMARKS.**—This species is easy of determination, both in the field and the herbarium. The bark is very characteristic, being smooth, firm, and very hard, and difficult to remove, even after the timber is cut. The leaves have somewhat the resemblance of “Mallee Box,” *E. Woollsiana*, R.T.B., from which species it differs in having a smooth bark, its inflorescence, timber, and chemical constituents. It is a strong species and Mueller's figure of it in the “*Eucalyptographia*” is very good.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Wyalong, N.S.W., in December, 1900. The yield of oil was 0.62 per cent. The crude oil was of a reddish-brown colour, and had an odour resembling those of the cineol-pinene class of *Eucalyptus* oils. It was fairly rich in cineol; pinene was present, but phellandrene could not be detected. It is doubtful if the aldehyde aromadendral occurs, as the rotation of the crude oil and of the higher boiling portion was more highly dextro-rotatory than was that of the first fraction. It is probable that a constituent exists in this oil, similar to that in *E. Rossii* and other species. The specific gravity of the oil was high, but it was less rich in cineol than those from such “Mallees” as *E. polybractea* and *E. oleosa*. The third fraction contained the sesquiterpene.





**REMARKS.**—This species is very constant in its specific character throughout its geographical distribution, and shows no disposition to variation. Mueller synonymised it with *E. hæmastoma*, Sm., as a variety, but it only resembles that species in the shape of the fruit. The leaves, fruits, oil, and timber easily distinguish it from *E. hæmastoma* of Smith. This is not *E. hæmastoma*, var. *micrantha*, which is a true varietal form of the species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Cow Flat, Bathurst, N.S.W., in March, 1901. The yield of oil was 0.72 per cent. The crude oil was of a dark amber colour; and had an odour reminding of peppermint, although piperitone could only be present in very small quantity. It was fairly rich in cineol; pinene was present, but phellandrene not detected. The presence of a high-boiling constituent which had a high rotation to the right was well shown; this is the liquid form of eudesmol. The oil of this species differed greatly from that of *E. hæmastoma*, of Smith, the "Scribbly Gum" of the coast, and also from that of "Scribbly Gum" growing around Lawson, and other places on the Blue Mountains, N.S.W.

The crude oil had specific gravity at 15° C. = 0.9215; rotation  $a_D + 7.2^\circ$ ; refractive index at 20° = 1.4684, and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 7.95.

On rectification, about 1 per cent. of acid water and volatile aldehydes came over below 165° C. (corr.). Between 165–183°, 69 per cent. distilled; between 183–233°, 14 per cent. came over, and between 233–280°, 11 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9108; rotation  $a_D + 4.8^\circ$ .

Second " " " = 0.9170; " + 4.3°.

Third " " " = 0.9499; " + 19.2°.

The cineol determined in the first fraction by the phosphoric acid method was 49 per cent. (O.M.), indicating about 40 per cent. in the crude oil.

Material of this species had previously been sent from Bungendore, N.S.W., in March, 1899. The oils were practically identical in every respect, with the exception that a little more pinene was present. The specific gravity of the crude oil at 15° was 0.9168. Below 183°, 78 per cent. distilled; between 183–240°, 9 per cent., and between 240–280°, 7 per cent. The crude oil was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9096; rotation  $a_D + 5.6^\circ$ .

Second " " " = 0.9205; " + 3.8°.

Third " " " = 0.9492; " + 18.7°.

The cineol determined in the large fraction by the phosphoric acid method was 52 per cent. (O.M.), indicating about 42 per cent. in the crude oil.

On the completion of the analyses, the two oils were mixed and stored in the dark. In August, 1919, the sample was again analysed. After twenty years but little alteration was observed in the oil of this species; and on rectification, 80 per cent. distilled below 190° C. The results with the crude and rectified oils were as follow:—

Crude oil, sp. gr. at 15° C. = 0.9205; rotation  $a_D + 7.5^\circ$ ; refractive index at 20° = 1.4677.

Large fraction " " = 0.9126; rotation  $a_D + 5.7^\circ$ ; refractive index at 20° = 1.4610.

The cineol was determined by the resorcinol method in the large fraction and calculated for the crude oil; the result was 64 per cent. By the phosphoric acid method it was 55 per cent.



In November, 1913, material of this species for distillation was received from Cooma, N.S.W. The yield of oil was 0.52 per cent. The results agree very closely with those previously obtained for the oil of this species. Phellandrene was absent, but pinene was present, and also a fair amount of cineol. Crystallised eudesmol was not detected, although the liquid form was present in some quantity. The crude oil had the following characters:—

Specific gravity at 15° C. = 0.9243; rotation  $a_D + 9.8^\circ$ ; refractive index at 20° C. = 1.4683, and was soluble in 1½ volumes 70 per cent. alcohol.

The cineol was determined by the phosphoric acid method; the result was 45 per cent.

**The high-boiling dextro-rotatory alcohol.**—Crystallised eudesmol has not at any time been detected in the oil of this species under ordinary conditions, but efforts to determine the identity of the alcohol resulted in the reversion of the liquid to the crystallised form. The mixed oil of this species, which had been stored for nearly twenty years, was taken for this investigation.

The saponification number for the oil was 6.13; after acetylation, it was 38.55. This result is equal to 13 per cent of free alcohol considered as  $C_{15}H_{25}OH$ .

800 c.c. of the crude oil gave 160 c.c. boiling above 192° C., equal to 20 per cent.; 157 c.c. of the high-boiling portion when distilled under reduced pressure, gave the following fractions:—

Between 78–134° C. at 6 millimetres, 58 c.c. distilled.

„ 134–150° C. „ „ 34 c.c. „

„ 150–166° C. „ „ 37 c.c. „

The last two fractions gave the following results:—

No. 2 fraction, sp. gr. at 15° C. = 0.957; rotation  $a_D + 9.0^\circ$ ; refractive index at 20° = 1.4950.

No. 3 „ „ „ = 0.972; rotation  $a_D + 19.6^\circ$ ; refractive index at 20° = 1.5150.

Fraction No. 2, on standing about fourteen days, formed a buttery-like mass, and had commenced to crystallise. Fraction No. 3 commenced to crystallise after standing overnight, and eventually became wholly crystalline.

Both fractions were then utilised for the preparation of the pure eudesmol. The melting point of this was 79–80° C., and in a 12 per cent. chloroform solution, gave specific rotation  $[a]_D + 33.58^\circ$ .

See also the article on eudesmol in this work, where the properties and peculiarities of this interesting substance are dealt with.

## 54. *Eucalyptus salmonophloia*.

(F.v.M., in *Fragm.* xi, II, 1878.)

**Salmon-coloured Gum.**

**Systematic.**—A tree when aged, reaching 100 feet in height, the bark smooth, grey, and somewhat purplish, of an oily lustre. Abnormal leaves ovate to ovate-lanceolate, dull on both sides. Normal leaves narrow-lanceolate, acuminate, falcate, 3 inches long, shining on either side; venation very indistinct, intramarginal vein scarcely removed from the edge, lateral veins spreading,

inclined at about  $45^\circ$  to the mid-rib. Peduncles 3 to 4 lines long, at first axillary, bearing umbels of about six flowers. Buds shining. Calyx tube semi-ovate, little more than one line long, on a pedicel of equal length; operculum conoidal, semi-ovate, as long or slightly longer than the tube.

**Fruit.**—Small, hemispherical to pilular, shining; rim narrow, slightly domed; valves acuminate, much exserted;  $1\frac{1}{2}$  lines long and  $1\frac{1}{4}$  lines in diameter.



*Similar in shape and differs only in the minutest details from those of E. oleosa.*

**Habitat.**—Western Australia.

**REMARKS.**—It is just possible this may be the Western tree-form of *E. oleosa*, for these species have much in common, and the physical and chemical properties are not easy to separate.

**ESSENTIAL OIL.**—Material for distillation was received from Western Australia in August, 1904. The exact locality from which the leaves were collected is not known, but the consignment was forwarded from Perth. The material had been collected as is usual for commercial purposes. The yield of oil was 1.44 per cent. The crude oil was reddish in colour, indicating the presence of phenols, and an odour representative of the cineol-pinene Eucalyptus oils generally, with a secondary one suggesting aromadendral. The principal constituents in the oil were dextro-rotatory pinene, cineol, and a sesquiterpene. Phellandrene was not present, and the amount of volatile aldehydes was small. High-boiling constituents were only present in small amount, and 92 per cent. distilled below  $183^\circ$  C. The lævo-rotation of the higher boiling fraction was due to the aromadendral. Although the oil contained a fair amount of cineol, yet it was deficient in the quantity demanded by the British Pharmacopœia standard.

The crude oil had specific gravity at  $15^\circ$  C. = 0.9076, rotation  $a_D + 6.3^\circ$ ; refractive index at  $20^\circ$  = 1.4681, and was soluble in  $3\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.9.

On rectification 1 per cent. distilled below  $166^\circ$  C. (corr.). Between  $166$ – $172^\circ$ , 40 per cent. distilled; between  $172$ – $183^\circ$ , 50 per cent. came over, and between  $183$ – $224^\circ$ , 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^\circ$  C. = 0.8973; rotation  $a_D + 10.6^\circ$ .

Second „ „ „ = 0.9077; „ +  $4.6^\circ$ .

Third „ „ „ = 0.9194; „ —  $3.0^\circ$ .

The cineol, determined by the phosphoric acid method in the crude oil, was 48 per cent. (O.M.).

The rectified oil boiling below  $183^\circ$  (90 per cent. of the whole) had specific gravity at  $15^\circ$  = 0.9052, and gave a return of 52 per cent. cineol, when determined by phosphoric acid (O.M.).

The oil of this species is thus a fair one, but owing to the comparative absence of high-boiling constituents the gravity is low.

The results obtained with the oil of this species were published by us in the Pharmaceutical Journal, London, September, 1905.



## 55. *Eucalyptus Seeana*.

(J.H.M., Proc. Linn. Soc., N.S.W., 1904, p. 469.)

(Syn. *E. tereticornis* Sm., var. *linearis*, R.T.B. & H.G.S., in Euc. and their Ess. Oils, 1st Edit., 1902.)

**Systematic.**—Abnormal leaves linear, lanceolate, often over 6 inches long, from 3 to 6 lines broad. Flowers pedicellate, almost sessile in some cases. Calyx often angular; opercula, outer one early removed in the budding stage, inner and persistent one conical, acute to ellipsoid, obtuse or shortly acuminate.

**Fruit.**—Hemispherical; with a less domed rim than type, and a flange below the edge; valves opening from below the inner edge of the rim, and more divergent than in the type.

*The fruits are exactly the same shape and size as the type, so that the best feature to distinguish it from its congeners is the bullet-shaped operculum.*



**Habitat.**—Coast districts, New South Wales, and Queensland.

**REMARKS.**—This variety was founded originally on the distinguishing characters of its abnormal leaves and operculum, timber and oil constituents. The flowers are shortly pedicellate, and the calyx often angled at the base. Being our own variety, it was our intention, as stated by us, to give it specific rank later, but Mr. Maiden, Linn. Soc. N.S.W., Vol. 29, 1904, states when describing *E. Seeana* that presumably this is *E. tereticornis*, Sm. var. *linearis*, Baker and Smith. It certainly is.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Woodburn, New South Wales, in August, 1900. The yield of oil was 0.78 per cent. The crude oil was red in colour, and had an odour resembling those of the cineol-pinene class. The oil was rich in cineol, contained some pinene, but phellandrene was absent. The amount of high boiling constituents was small, and consequently the specific gravity of the rectified oil was not high enough to meet the requirements of the standard as fixed by the British Pharmacopœia.

The crude oil had specific gravity at 15° C. = 0.91; rotation  $\alpha_D + 5.6^\circ$ ; refractive index at 20° = 1.4649, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.5 per cent.

On rectification 2 per cent. distilled below 165° C. (corr.). Between 165–183°, 88 per cent. distilled; between 183–243°, 8 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9076; rotation  $\alpha_D + 6.3^\circ$ .

Second " " " = 0.9243; " + 5.6°.

The cineol determined by the phosphoric acid method in the large fraction was 57 per cent. (O.M.), indicating about 52 per cent. in the crude oil.

The above sample of oil had been stored in the dark, and in September, 1919, was again analysed. It had become much heavier during that time, but



on rectification 80 per cent. came over below  $190^{\circ}$ . This fraction appeared to consist very largely of cineol, suggesting an increase of cineol in the oil during the nineteen years it had been kept. The crude oil and the large fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9690; rotation  $a_D + 4.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.470.

Large fraction „ „ = 0.9290; rotation  $a_D + 3.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4610.

The cineol was determined by the resorcinol method in the portion distilling below  $190^{\circ}$ ; when calculated for the crude oil, the result was 76 per cent. By the rapid phosphoric acid method it was 58 per cent. when calculated for the crude oil.

## 56. *Eucalyptus rostrata*, var. *borealis*.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, 1st Edit., 1902.)

### River Red Gum.

**Systematic.**—It has long been known by stockmen that cattle will eat the leaves of only one kind of “River Gum” (*E. rostrata*, Schl.), but which kind it does not seem possible to differentiate in the herbarium. Morphologically, no variations could be detected between the Murray River specimens and those received from Broken Hill and Nyngan, but they differed, however, in chemical constituents, and this probably partly accounts for this choice of trees by stock. After our experience with *E. apiculata*, we have little doubt but that morphological differences do exist between these two Eucalypts, and will yet be found, so that a systematic description can be given for each species. On chemical grounds, we have decided to separate the Northern “River Gum” from the Southern “River Gum” under the varietal name of *borealis*.

For the data in reference to the type *E. rostrata*, see under that species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nyngan, New South Wales, in December, 1899. The yield of oil was 0.8 per cent. Pinene was found, but phellandrene was quite absent. Constituents having a high-boiling point were present only in small amount.

The oil of this tree is rich in cineol, and the leaves might be distilled commercially, but oil could not be profitably extracted from the leaves of the type *E. rostrata*.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9109; rotation  $a_D + 5.46^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4654, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.8.

On rectification 2 per cent. distilled below  $170^{\circ}$  C. (corr.). Between  $170$ – $183^{\circ}$ , 85 per cent. distilled; between  $183$ – $250^{\circ}$ , 5 per cent. distilled.

The specific gravity of the first fraction at  $15^{\circ}$  C. = 0.909, of the second fraction = 0.9142. The rotation of the first fraction  $a_D + 6.37^{\circ}$ .

The cineol determined by the phosphoric acid method in the first fraction was 52 per cent. (O.M.), indicating about 45 per cent. in the crude oil.

Material of this species was also obtained from near Broken Hill, New South Wales, in July, 1898. The yield of oil was 1.19 per cent. The constituents in this oil and its general characters agreed very well with that from the Nyngan material. The specific gravity at  $15^{\circ} = 0.9065$ , saponification number = 8, and the oil was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The cineol determined by the phosphoric acid method in the crude oil was 48 per cent. (O.M.).

Oil was distilled from this species by Mr. P. R. H. St. John in 1916, from trees cultivated in Melbourne, and forwarded to the Museum for investigation. The yield of oil he obtained was 0.83 per cent. The crude oil had specific gravity at  $15^{\circ} = 0.9153$ ; rotation  $\alpha_D + 3.5^{\circ}$ ; refractive index 1.4583, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 6.6. The cineol in the crude oil determined by the resorcinol method was 69 per cent. It is thus seen that this oil agrees fairly well with the above samples from Nyngan and Broken Hill, and differs entirely from the oil of the type *E. rostrata*, which species gives equally constant oil results. (See under that species.)

## 57. *Eucalyptus camphora*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 298, t. XXII.)

**Sallow or Swamp Gum.**

**Systematic.**—A small tree, about 20 to 40 feet high in northern specimens, but a fair sized tree in the south. Abnormal leaves ovate, obtuse, under 6 inches long,  $3\frac{1}{2}$  inches broad, on angular petioles of  $\frac{1}{2}$  inch long, coriaceous, glaucous. Normal leaves ovate-elliptical, abruptly acuminate, under 4 inches long, or lanceolate, acuminate and 6 inches long, thinly coriaceous, glaucous; venation distinct, particularly in young leaves, intramarginal vein removed from the edge. Peduncles few, axillary, flattened, bearing five or six short pedicellate or sessile buds. Calyx turbinate, inclining to hemispherical, 1 line long, 1 line broad; operculum acuminate, about 2 lines long.

**Fruit.**—Small, turbinate; rim flat; valves exserted; 3 lines long and 2 lines in diameter.

*The fruits with care can generally be distinguished from E. paludosa (which they resemble in shape), by their smaller size.*



**Habitat.**—It was discovered (R.T.B.) at Ganguddy Creek, Kelgoola, Rylstone, in 1895, afterwards in 1897 at Narango and since recorded from the South Coast, N.S.W., well into Victoria.





R.T.B., del. ad nat.

**EUCALYPTUS CAMPHORA, R.T.B.**  
SALLOW OR SWAMP GUM.





**REMARKS.**—It is an umbrageous tree, attaining a height from 30 to 100 feet, and a diameter up to 3 feet, but usually rather crooked and essentially a swamp or wet ground species. It must not be confused with other species such as *E. ovata*, Labill and *E. Gunnii*; the former is a Western Australian species, and the latter is fully shown by us in this and other publications to be also distinct. From *E. paludosa*, R.T.B., it is easily distinguished, especially so in older trees, the leaves being broader and more oval, and the apex quite blunt, sometimes obcordate, whilst the timbers readily differentiate the species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Heydon's Bog, Delegate, N.S.W., in February, 1899. The yield of oil was 1.34 per cent. The crude oil was amber coloured, and had an odour resembling those belonging to the cineol-pinene class, but with a pronounced odour of volatile aldehydes. Eudesmol was present in considerable quantity. The oil was rich in cineol, contained pinene, but phellandrene was absent. At one time a good deal of oil was distilled commercially from this species in New South Wales.

The crude oil had specific gravity at 15° C. = 0.9071; rotation  $a_D + 1.3^\circ$ ; refractive index at 20° = 1.4676; and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.4.

On rectification a few drops came over below 160° C.; the thermometer then rose rapidly to 170° (corr.). Between 170–190°, 91 per cent. distilled, the remainder consisted almost entirely of eudesmol.

The rectified oil had sp. gr. at 15° = 0.9065; rotation  $a_D + 1.45^\circ$ . The cineol determined by the phosphoric acid method was 54 per cent. (O.M.), indicating about 50 per cent. in the original oil.

Material of this species was also obtained from Rylstone, N.S.W., in September, 1898. The oil at this time of the year was found to contain such an abundance of eudesmol, that the fraction containing it solidified in the receiver. The oil was less rich in cineol than the Delegate sample, illustrating the influence the time of the year, and the eudesmol content, appear to have on the formation of cineol. The specific gravity of the crude oil at 15° = 0.9167. On rectification 61 per cent. distilled below 183°. This fraction had sp. gr. at 15° = 0.8967; and rotation  $a_D + 0.75^\circ$ , and a determination for cineol by the phosphoric acid method gave 33 per cent. (O.M.). No less than 18 per cent. distilled between 270–283°, which fraction consisted almost entirely of eudesmol.

## 58. *Eucalyptus Maidenii*.

(F.v.M., Proc. Linn. Soc., N.S.W., 1889, p. 1020, t. XXVIII and XXIX.)

### A Blue Gum.

**Systematic.**—Known as “Blue Gum” and “Spotted Gum” in different localities, and erroneously recorded as *E. globulus* from the Araluen district. It is always a tall straight growing tree, attaining a height up to 150 or even 200 feet, with a diameter up to 4 feet, with a smooth bark, chalky white, or bluish, hence its name “Blue Gum.” The abnormal leaves are very large, glaucous or even chalky white, round, or heart shaped, sessile and stem-clasping on the sharply angular and winged branchlets, gradually becoming alternate, petiolate, lanceolate







*R. T. Baker, del.*

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**EUCALYPTUS RODWAYI, R.T.B. & H.G.S.**

APPLE SCENTED OR BLACK GUM.



better than the oil of *E. globulus*, as the yield of oil is greater. It would be necessary, however, to rectify the oil before use, because the esters and volatile aldehydes are present in some quantity; but this remark applies to most of the richer cineol oils.

The above samples were mixed together and stored in the dark. In August, 1919, the oil was again analysed. It had not altered much in general characters. Ninety per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9264; rotation  $\alpha_D + 6.7^\circ$ ; refractive index at 20° = 1.4646.

Rectified portion „ = 0.9171; rotation  $\alpha_D + 7.0^\circ$ ; refractive index at 20° = 1.4610.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 77 per cent. By the rapid phosphoric acid method (duplicate determinations) the result was 62 per cent. when calculated for the crude oil. Terpeneol was detected in the rectified portion. After acetylation the saponification number was only 21, thus showing that bodies other than cineol and alcohols were absorbed by the resorcinol.

## 59. *Eucalyptus Rodwayi*.

(R.T.B. & H.G.S., Roy. Soc., Tas., 1912, p. 191, t. II.)

**Apple-Scented or Black Gum.**

**Systematic.**—A large forest tree; often 4 feet in diameter. Bark persistent on stem and branches. Abnormal leaves alternate, oval lanceolate to ovate lanceolate, 3 inches long and about  $\frac{1}{2}$  inch broad, inclined to falcate, petiolate, almost membranous; venation not pronounced, lateral veins distinctly oblique at the base and less so towards the apex. Normal leaves lanceolate, sometimes falcate, up to 6 inches long, but usually under 4 inches, and  $\frac{1}{2}$  inch wide, thicker than abnormal leaves; venation not prominent, intramarginal vein slightly removed from the edge. Peduncles axillary or lateral, about 3 lines long, usually bearing under six flowers. Calyx tube about 2 lines, shortly pedicellate; operculum conical, acuminate.

**Fruit.**—Conical or hemispherical, to slightly pyriform; rim convex, sometimes cracked transversely; valves slightly exserted; under 2 lines long and 2 lines in diameter.



*These so resemble those of E. Macarthuri and E. aggregata that without taking into account other physical characters all these species may easily be confounded.*

**Habitat.**—Deloraine (Maiden and Cambage). Between Interlaken and Tunbidge, at an elevation of 3,000 feet and down the western slopes to quite a low altitude; also Strickland, Tasmania (L. G. Irby).



**REMARKS.**—A species endemic to Tasmania, with specific characters distinct from any of the mainland Eucalypts, although Maiden synonymised it in Roy. Soc. Tas., 1914, p. 30, under *E. aggregata*, D. & M., but our results for this species do not agree with the physical and chemical properties described under that species, any more than they do when it was considered to be *E. Macarthuri*.

**ESSENTIAL OIL.**—Material of this species for distillation was collected at Deloraine, Tasmania, in June, 1912. The crude oil when cleared was light olive-brown in colour, and had a terpene-like odour, together with that of cineol, but with no resemblance to geranyl-acetate. It contained pinene as the chief terpene, and phellandrene could not be detected. It was rich in cineol, over 60 per cent. of the crude oil being that constituent. The saponification number for the esters and free acid was only 3.96, representing 1.38 per cent. of ester if calculated as geranyl-acetate. The amount of ester in the oil of this species is thus low. The yield of oil was 0.48 per cent., too small an amount to render the oil of commercial value.

The crude oil had specific gravity at 15° C. = 0.9075; rotation  $a_D + 10.6^\circ$ ; refractive index at 20° = 1.4671; and was soluble in 6 volumes 70 per cent. alcohol.

On rectification, the usual amount of acid water and volatile aldehydes were obtained below 164° C. (corr.), at which temperature the oil commenced to distil. Between 164–173°, 33 per cent. distilled; between 173–198°, 57 per cent. came over, and between 198–265°, 5 per cent. distilled. The high-boiling fraction contained a constituent with rotation to the right, but it was not isolated. It was apparently the liquid form of eudesmol. The following results were obtained with the several fractions:—

|                                        |                                                                                             |
|----------------------------------------|---------------------------------------------------------------------------------------------|
| First fraction,                        | sp. gr. at 15° C. = 0.8979; rotation $a_D + 15.8^\circ$ ; refractive index at 20° = 1.4611. |
| Second        ,,        ,,        ,,   | = 0.9119; rotation $a_D + 8.4^\circ$ ; refractive index at 20° = 1.4620.                    |
| Third         ,,         ,,         ,, | = 0.9231; rotation $a_D + 5.2^\circ$ ; refractive index at 20° = 1.4787.                    |

The cineol, determined by the resorcinol method in the oil distilling below 198° C., and calculated for the crude oil, was 64 per cent. By the rapid phosphoric acid method the result was 50 per cent., when calculated for the crude oil. After acetylation the saponification number was 24.5, thus showing the presence of bodies, other than alcohols, absorbable by resorcinol. The rectified oil had a yellowish tinge, a peculiarity often found with the cineol-pinene oils distilled from the leaves of the smooth bark "Gums" like *E. globulus*, *E. goniocalyx*, &c. Pinene was isolated from the first fraction, and proved to be that substance by the formation of the nitrosochloride, which melted at the correct temperature for that substance.

This species has no close connection with *E. Macarthuri* of New South Wales, as the oil of that species appears never to contain less than 60 per cent. of geranyl-acetate at any time of the year, the ester often rising to 75 per cent., and one determination of the oil from the abnormal leaves showed that it contained over 77 per cent. of geranyl-acetate. Cineol does not appear to occur in the oil of *E. Macarthuri*, although pinene is usually present in small amount.

The results of this investigation were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.



R.T.B., dd.

**EUCALYPTUS CINEREA, F.V.M.**  
ARGYLE APPLE.





## 60. *Eucalyptus cinerea*.

(F.v.M., in B. Fl., iii, p. 239.)

**Argyle Apple.**

**Systematic.**—A picturesque tree, from 40 to 50 feet high, having a foliage covered with a whitish bloom. Bark whitish brown or reddish, fibrous, thick, extending almost to the branchlets. Leaves opposite, sessile, cordate, ovate, ovate-lanceolate, or lanceolate, on a short petiole; venation generally well marked, oblique, intramarginal vein removed from the edge. Peduncles axillary, flattened or terete, very short, bearing mostly three flowers, sessile or nearly so; calyx obconical, 2 to 3 lines long; operculum hemispherical, shortly acuminate.

**Fruit.**—Sessile and hemispherical, or pyriform; rim thick, domed; valves short, rarely exserted; 2 to 3 lines in diameter.



*Fruits are not unlike those of E. pulverulenta.*

**Habitat.**—Counties of Camden and Argyle, Lake George, New South Wales; Toongabbie to Walhalla, Victoria.

**REMARKS.**—Baron von Mueller in his "Eucalyptographia" unites this species with Sim's *E. pulverulenta*, but it is only under a much restricted classification that this would hold, for when seen in their native habitat, no two trees could be more unlike each other than are these two. Benthams, however, agrees with the original author, and separates the species (B.Fl. iii, pp. 224, 239). Unfortunately for recent botanical workers, Mueller erroneously figures this particular species (*E. cinerea*) when illustrating what he considered to be *E. pulverulenta* (*loc. cit.*); this has led to much confusion, and we ourselves did not discover this fact till late in the research for the first edition. In Mueller's numerous references to *E. pulverulenta* in his "Eucalyptographia," it is undoubtedly *E. cinerea* that is meant, as it is that tree, the "Argyle Apple" which has a reddish, stringy-bark, and a reddish-coloured timber similar to *E. Stuartiana*, the "Apple" of Victoria, and Mueller often states that he was inclined to consider these two latter identical. We are of the opinion, from our examination of the material of *E. Stuartiana*, *E. pulverulenta*, *E. cinerea*, and *E. Bridgesiana*, that they are all good and distinct species. Unfortunately, most of the Eucalyptus vernacular names are misleading, one name being applied to several distinct species, but *E. cinerea* is an example in which one common name is applied to the one species, and not to several others, so that in this particular instance there can be no mistaking the tree locally, however much the botany may be in doubt.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, New South Wales, in January, 1900. The yield of oil was 1.2 per cent. The crude oil was red in colour, and had a pronounced odour of volatile aldehydes. A rather large amount of esters appear always to be present in the oil of this species, consequently it had a tendency to become acid, particularly if rectified by direct distillation under atmospheric pressure. Pinene was always present, varying slightly in amount at different times of the year; but phellandrene was absent. The oil was rich in cineol, and when properly rectified, of good quality for pharmaceutical purposes. The crude oil had usually a high specific gravity, but contained a minimum of high-boiling constituents for an oil of this class, although the ester content was considerable. During the summer the specific gravity of the oil was usually lower than in the winter, as the terpenes of low boiling point are then present in a maximum amount.

The crude oil had specific gravity at 15° C. = 0.9113; rotation  $a_D + 3.05^\circ$ ; refractive index at 20° = 1.4649, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 24.

On rectification 2 per cent. distilled below 168° C. (corr.). This portion consisted largely of the two aldehydes, butaldehyde and valeraldehyde. Between 168–188°, 89 per cent. distilled. The distillation was not carried further.

This fraction had sp. gr. at 15° C. = 0.9094; rotation  $a_D + 3.2^\circ$ .

PLATE XXVII.



M. F. Connelly, Photo.]

**EUCALYPTUS CINEREA, F.v.M.**  
"ARGYLE APPLE."

This photograph shows the foliaceous character of this species.

TOWRANG, N.S.W.

The cineol, determined by the phosphoric acid method in the rectified portion, was 59 per cent. (O.M.), indicating about 54 per cent. in the crude oil.

The rectified oil was yellow in tint, as is usual with the oils of this class. This colour is traceable to the influence of the phenol australol.

Leaves and branchlets of this species for distillation were also obtained from the following localities:—Barber's Creek, New South Wales, in September, 1899; Towrang, in August, 1900; Barber's Creek, in November, 1896; Barber's Creek, in September, 1897. The oils from all this material were found to be fairly constant in general characters; and the percentages of esters, cineol content, optical rotations, and yields of oil were all practically in agreement, only varying in the amounts usual with the oil of a particular species, distilled at varying times of the year.



The following tabulated results obtained with the crude oils will show the range of differences between the several samples:—

| Date and Locality.                                  | Specific gravity at 15° C. | Optical Rotation $a_D$ | Saponification number for esters and free acid. | Percentage yield of oil. |
|-----------------------------------------------------|----------------------------|------------------------|-------------------------------------------------|--------------------------|
| <i>E. cinerea</i> , Barber's Creek, Nov., 1896 ...  | 0.9186                     | + 4.1°                 | 15.9                                            | 1.2                      |
| <i>E. cinerea</i> , Barber's Creek, Sept., 1897 ... | 0.9157                     | + 3.5°                 | 16.5                                            | 1.3                      |
| <i>E. cinerea</i> , Barber's Creek, Sept., 1899 ... | 0.9225                     | + 2.5°                 | 14.4                                            | 1.0                      |
| <i>E. cinerea</i> , Barber's Creek, Jan., 1900 ...  | 0.9113                     | + 3.05°                | 24.0                                            | 1.2                      |
| <i>E. cinerea</i> , Towrang, Aug., 1900 ...         | 0.9168                     | + 3.6°                 | 21.1                                            | 1.3                      |

Considerable quantities of oil were commercially distilled from this species at one time in the Towrang district of New South Wales, particularly by the Australian Eucalyptus Oil Company, and we were thus able to test numerous samples of this commercially distilled oil. It was not found to differ in constituents or general characters at any time, beyond what might be expected with the oil from any one species. The specific gravity of the crude oil varies between 0.91 to 0.9225, the rectified oil being in agreement. The saponification number of the esters and free acid in the crude oil usually ranges between 14 and 24. As the trees are somewhat gregarious, with plenty of foliage, which yields a fair percentage of a good oil, this species may be considered of value for Eucalyptus oil distillation.

The above oils were mixed together and stored in the dark, and in August, 1919, the sample was again analysed; it had increased a little in specific gravity, as was to be expected from the formation of the insoluble deposit, and for the same reason had increased in cineol content. 86 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9238; rotation  $a_D$  + 4.0°; refractive index at 20° = 1.4627.

Rectified portion : „ = 0.9170; rotation  $a_D$  + 4.5°; refractive index at 20° = 1.4604.

The saponification number was 18.5 and after acetylation 55.4, equal to 10.5 per cent. of free alcohol, with a  $C_{10}H_{18}O$  molecule.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 72 per cent. By the rapid phosphoric acid method it was 60 per cent. when calculated for the crude oil. Terpeneol was detected in the rectified portion, which gave an alcohol value equal to 8 per cent.

The red colour of the cineol-pinene crude Eucalyptus oils is traceable to the free acid attacking the iron of the stills, the iron reacting on the phenols, consequently the colour may be removed by agitating with a solution of sodium hydrate. In commercial distillation of the leaves, copper still-heads were at one time generally used, but it was soon found that copper fittings for this purpose were unnecessary and objectionable, because the free acid in many of the oils readily dissolved the copper, so that the crude oil became of a greenish



colour in consequence. This was particularly the case with the oil of *E. cinerea*, and it was found that if care were not taken in the rectification, copper could be detected in the distillate. When iron alone was present in the oil this did not occur, so that eventually copper fittings were in most cases discarded.

As an illustration of the amount of copper likely to occur in oils of this class, if copper fittings are used, the following is given:—When crude Eucalyptus oils are rectified by direct distillation, a portion of the water absorbed in the oil comes over in the first distillate, and this contains practically the whole of the free volatile acid occurring in the oil. Our thanks are due to the Australian Eucalyptus Oil Company for supplying us with about two litres of this water, which they had collected when rectifying the crude oil of *Eucalyptus cinerea*. This water was strongly acid, and of a bright green colour, due to the presence of the copper in solution. The water had also a strong odour of the volatile aldehydes. It was made alkaline by the addition of sodium hydrate, the precipitated copper filtered off, and the precipitate dried and ignited. The copper was then dissolved out, and finally precipitated as metal on a platinum dish. The amount of metallic copper thus obtained from 2 litres of water was 0.8772 gram., equal to 0.0438 per cent. It must be remembered, too, that this result only represented that portion of the copper which came over on redistillation.

The amount of free acetic acid in the water was determined by titrating 10 grams. with semi-normal soda. The amount of NaOH used was 0.140 grams., equal to 2.1 per cent. acetic acid. (See also the article on "The Free Volatile Acid of Eucalyptus Oils.")

## 61. *Eucalyptus dealbata*.

(A. Cunn., Schau. in Walp. Rep., ii, 924.)

**Cabbage, White Gum, or Mountain Gum.**

**Systematic.**—A fair-sized tree, from 60 to 80 feet high, with a smooth bark, which is occasionally rough at the base. Abnormal leaves lanceolate, acuminate, or shortly so, 4 to 6 inches long, and under 2 inches broad, pale bluish; intramarginal vein well removed from the edge, especially in the short broader leaves. Normal leaves lanceolate, generally under 6 inches long, not shining; venation well marked, lateral veins oblique, spreading, intramarginal vein removed from the edge. Peduncles axillary, short, 4 lines long, with four to six flowers in the umbel. Calyx conical, about 2 lines long; pedicel short or long, occasionally angular; operculum conical, obtuse, equal to or longer than the calyx.

**Fruit.**—Hemispherical; rim flat, or slightly convex; valves acuminate, exserted, often resembling those of *E. oleosa*, F.v.M.; 2 lines long and  $2\frac{1}{2}$  lines in diameter.



*The fruits are constant in shape, not unlike those of E. resinifera with the truncate rim, but somewhat smaller.*

**Habitat.**—Condobolin to Manildra, Cowra, Grenfell, Tenterfield, Murrumbo, Rylstone, New South Wales; Victoria; Queensland.



R.T.B., del.

**EUCALYPTUS DEALBATA, A. CUNN.**  
A MOUNTAIN GUM.

no. 1000  
APPROVED



**REMARKS.**—A good-sized, straight-stemmed tree; except for the greyish tinge of the foliage, it resembles in appearance *E. punctata*, DC., the trunks having the same general grey colour, but with lighter coloured patches on them. There has been some doubt in the past whether this tree should not be placed with *E. tereticornis*, Sm., but timber, bark, and fruits, as well as the oil differ from those of that species, and as these characters are constant throughout its extensive distribution, *i.e.*, east and west of the Great Dividing Range, it has been decided to retain Cunningham's naming. A feature of the inflorescence is the very small, brown-coloured, second operculum, which comes off early in the bud stage.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Condobolin, New South Wales, in March, 1901. The yield of oil was 0.85 per cent. The crude oil was the colour of olive oil, and had an odour resembling those of the cineol-pinene class. It was rich in cineol, contained some pinene, but phellandrene was absent. The higher boiling portion consisted largely of the sesquiterpene, together with a high boiling dextro-rotatory alcohol. The rectified oil had a yellowish tint, resembling, in this respect, those belonging to this class. The oil is a good one for pharmaceutical purposes.

The crude oil had specific gravity at 15° C. = 0.9261; rotation  $a_D + 3.8^\circ$ , refractive index at 20° = 1.4648, and was soluble in  $1\frac{3}{4}$  vols. 70 per cent. alcohol. The saponification number for the esters and free acid was 2.1.

On rectification a small amount of acid water and volatile aldehydes came over below 166° C. (corr.). Between 166–183°, 88 per cent. distilled; between 183–255°, only 2 per cent. came over, and between 255–268°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9193; rotation  $a_D + 2.6^\circ$ .

Third                   "                   "                   " = 0.9460;                   "                   " not taken.

The cineol determined by the phosphoric acid method in the large fraction was 58 per cent. (O.M.), indicating about 52 per cent. in the crude oil.

This sample of oil had been stored in the dark, and in September, 1919, eighteen years afterwards, was again analysed. Very little alteration had taken place in the oil during all that period, except that it was richer in cineol, in fact, the rectified oil consisted principally of cineol and pinene.

On redistilling, 90 per cent. came over below 190° C. The crude oil and large fraction gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9290; rotation  $a_D + 3.6^\circ$ ; refractive index at 20° = 1.4649.

Large fraction                   "                   " = 0.9228; rotation  $a_D + 2.5^\circ$ ; refractive index at 20° = 1.4594.

The cineol was determined by the resorcinol method in the portion distilling below 190°; when calculated for the crude oil the result was 87 per cent. By the rapid phosphoric acid method it was 73 per cent., when calculated for the crude oil.

## 62. *Eucalyptus resinifera*.

(Sm. in White's Voy., 231; in Trans. Linn. Soc., iii, 284.)

**Red or Forest Mahogany.**

**Systematic.**—A tall forest tree extending throughout nearly the whole range of the coast district of New South Wales into Southern Queensland. Leaves lanceolate, rather large and broad, thick, drying a light green colour on both sides; venation faint, the lateral veins almost transverse and parallel, the intra-marginal vein close to the edge. Umbels axillary, stalk compressed, number of flowers varying up to twelve in an umbel. Buds pedicellate. Calyx hemispherical; operculum conical (sometimes several lines long), or hemispherical and acuminate.

**Fruit.**—Hemispherical; rim flat or slightly round; valves acutely acuminate, well exserted; usually about 3 lines in diameter.

*The truncate rim and the sharp exserted valves are characteristic, and are the best guides in identifying the tree. E. dealbata is much the same shape, but smaller.*



**Habitat.**—The Coast district of New South Wales and Queensland.

**REMARKS.**—One of the largest forest trees of N.S.W. The common name has been given to it in allusion to the timber somewhat resembling the Honduras Mahogany. On a cortical classification, it would be placed in the "Stringybarks," as its bark is much more stringy than many Eucalypts known by that name. The fruits are characteristic, the hemispherical shape and flat rim being constant. The variety *grandiflora*, of Bentham (B.Fl. iii, 246), is, in this work, raised to its original specific rank of *E. hemilampra*, F.v.M. We find that *E. resinifera* presents little or no variation of form throughout its geographical distribution, and the present supposed varieties will no doubt be found to be good species under the original names of *E. spectabilis*, F.v.M., and *E. pellita*, F.v.M.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Gosford, New South Wales, in May, 1897. The yield of oil was 0.42 per cent. The crude oil was dark lemon in colour, and had an odour resembling those of the cineol-pinene class. The oil was rich in cineol, but did not contain phellandrene; the low-boiling terpene was pinene. Only a small quantity of high-boiling constituents was present, consequently the specific gravity was somewhat low.

The crude oil had specific gravity at 15° C. = 0.9098; rotation  $a_D + 2.25^\circ$ ; refractive index at 20° = 1.4698, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 9.2.

On rectification the usual amount of acid water with rather an excess of aldehydes came over below 170° C. Between 170-183°, 87 per cent. distilled; and 7 per cent. between 183-245°. These fractions gave the following:—

First fraction sp. gr. at 15° C. = 0.9072; rotation  $a_D + 2.45^\circ$ .

Second " " " = 0.9168; " not taken.

The cineol determined in the crude oil by the phosphoric acid method was 50 per cent. (O.M.). A precipitate formed in the crude oil on keeping, as do many of the oils belonging to this class. (See the article on this deposit.)

PLATE XXIX.



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Section near the edge of the leaf, three glands are seen. The palisade tissue is developed below the thickened edge of the upper surface of the leaf, and clearly demarcated from the spongy tissue. The edge of the leaf is backed by strengthening tissue stomata hypogenous. x 55.

EUCALYPTUS RESINIFERA. SM.



TO VIMU  
ADDITION

The above sample had been preserved in the dark, and in August, 1919, was again analysed. The alteration that had taken place in the oil during the 22 years it had been kept was not very pronounced; the specific gravity had increased somewhat, and a precipitate had formed; perhaps the cineol had also increased as indicated from the results with the fractionated oil.

On rectification 90 per cent. distilled below 190° C. The results with the crude and rectified oils were as follow:—

Crude oil, sp. gr. at 15° C. = 0.9249; rotation  $a_D + 3.0^\circ$ ; refractive index at 20° = 1.4699.

Fraction                    "                    "                    = 0.9133; rotation  $a_D + 2.4^\circ$ ; refractive index at 20° = 1.4651.

The cineol, determined by the resorcinol method in portion distilling below 190° and calculated for the crude oil, was 69 per cent. By the rapid phosphoric acid method it was 56 per cent. when calculated for the crude oil.

### 63. *Eucalyptus accedens*.

(W.V.F., in Jour. W.A. Nat. Hist. Soc., i, 21, 1904.)

**Systematic.**—A medium-sized tree, attaining a height of 60 feet, with a smooth persistent, greyish or white bark, blotched with patches of darker colour. Abnormal leaves broad-ovate, up to 6 inches long and 6 inches across, thick and coarse, petiolate, often cordate at the base. Normal leaves ovate to lanceolate, sometimes falcate, averaging 3 to 4 inches long, thick, often acuminate; venation not conspicuous, intramarginal vein not far removed from the edge, lateral veins inclined at about 40° to the mid-rib. Flowers about eight in umbels, the common peduncle axillary or lateral, slightly angular, about 8 lines long. Calyx tube turbinate, about 3 lines long, tapering to a pedicel not quite as long; operculum  $1\frac{1}{2}$  lines long, semi-ovoid, rounded at the apex.

**Fruit.**—Turbinate or sub-cylindrical, sometimes conoidal, scarcely or not contracted at the orifice; rim narrow, counter-sunk, grooved at the top and usually cracked transversely; valves slightly exserted; 4 to 5 lines long, 3 lines broad.



*Amongst the Eastern species the nearest in shape to these are E. ochrophloia and E. Fergusoni.*

**Habitat.**—Restricted to Western Australia.

**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were received from Mr. C. E. Lane-Poole, the Conservator of Forests, Western Australia. The material was collected in August, 1918. The yield of oil was 0.87 per cent. The crude oil was red in colour and had an odour similar to those of the cineol-pinene oils of the "Gum" group. The chief terpene was dextro-rotatory pinene; phellandrene was absent, and cineol only present in fair amount. Crystallised eudesmol was detected. The esters were mostly high-boiling, and the oil contained some sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9084; rotation,  $a_D + 13.4^\circ$ ; refractive index at 20° = 1.4691, and was soluble in 9 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.6.

On rectification, 1 per cent. distilled below  $158^{\circ}$  C. (corr.). Between  $158-172^{\circ}$ , 61 per cent. distilled; between  $172-193^{\circ}$ , 24 per cent. came over, leaving 14 per cent. boiling above  $193^{\circ}$ . The two fractions and the residue gave the following results:—

|                 |                                                                                                                  |
|-----------------|------------------------------------------------------------------------------------------------------------------|
| First fraction, | sp. gr. at $15^{\circ}$ C. = 0.8929; rotation $a_D + 17.4^{\circ}$ ; refractive index at $20^{\circ} = 1.4644$ . |
| Second          | „ „ = 0.9105; rotation $a_D + 6.5^{\circ}$ ; refractive index at $20^{\circ} = 1.4660$ .                         |
| Residue         | „ „ = 0.9582; rotation too dark; refractive index at $20^{\circ} = 1.4950$ .                                     |

The saponification number for the residue was 13.4, and in the cold with two hours' contact it was 13.1. The saponified oil was very aromatic.

The cineol was determined by the resorcinol method in the portion distilling between  $158-193^{\circ}$ ; when calculated for the crude oil, the result was 45 per cent. A determination by the rapid phosphoric acid method in the crude oil gave 43 per cent.

The rectified oil was tinged yellow, a feature common with the oils of the "Gum" group.

## 64. *Eucalyptus vernicosa*.

(Hook., f. in Lond. Jour. Bot., vi, 478, 1847.)

**Systematic.**—A bushy shrub or small tree, from 4 to 20 feet high. Bark smooth, dark red-brown, rough. Leaves alternate or opposite, oval, ovate or almost orbicular, crowded, thick, coriaceous, shining, obtuse or mucronate, shortly petiolate, mostly under 1 inch long; venation not prominent, lateral veins fairly transverse. The closely arranged leaf scars on the branchlets are very conspicuous. Flowers sessile, from one to three, on very short axillary, angular peduncles. Calyx tube thick, conical, often ribbed, 2 to 3 lines long; operculum shorter, acuminate.

**Fruit.**—Semi-ovoid or expanded slightly at the orifice; rim convex; valves not exerted or only slightly so; 3 lines long and almost 3 lines in diameter.



**Habitat.**—Confined to high elevations in Tasmania.

**REMARKS.**—Rodway suggests in his "Flora of Tasmania" (p. 58), that it is just possible that this species is a mountain form of *E. Muelleri*, but we are of opinion that technology at least, from a forestry or timber point of view, would be better served if the two were recognised as distinct—*vide* note under that species. "This *Eucalypt* has the same form of leaves throughout its life history, which *E. Muelleri* does not appear to have."—L. G. Irby.

**ESSENTIAL OIL.**—Material for distillation was obtained on the Hartz Mountains, Tasmania, in May, 1912, and reached Sydney in excellent condition. The yield of oil was 0.8 per cent. The crude oil was but little coloured, and was rich in cineol. It contained, however, rather a large amount of dextro-rotatory pinene, consequently the specific gravity was somewhat low; this result was also influenced by the remarkable freedom from high-boiling constituents, and no less than 96 per cent. of the crude oil distilled below  $194^{\circ}$  C. The terpene phellandrene was absent in the oil of this species.





rule in this respect. The principal constituents in the oil were dextro-rotatory pinene and cineol, over 50 per cent. of the latter constituent being present. Phellandrene does not occur, nor were either eudesmol, piperitone, or aromadendral detected. The ester was probably geranyl-acetate largely, as the greater portion was saponified in the cold with two hours' contact. The small amount of high-boiling constituents in the oil of this species caused it to have a specific gravity below 0.91 at 15° C., while the presence of the pinene in rather large excess gave a somewhat high dextro-rotation. The rectified oil, however, was practically colourless—almost water-white—and it had, for an ordinary Eucalyptus oil, a very agreeable odour, and nothing objectionable. The yield of oil from leaves with terminal branchlets was 1.13 per cent. The crude oil was reddish in colour, usual with oils of this class when the leaves are distilled from iron digesters. The specific gravity at 15° C. = 0.9088; rotation  $\alpha_D + 11.8^\circ$ ; refractive index at 20° C. = 1.4652, and was soluble in 5 volumes 70 per cent. alcohol.

On rectification, a small amount of acid water and volatile aldehydes, for oils of this class, came over below 165° C. (corr.). Between 165–174°, 54 per cent. distilled; between 174–193°, 36 per cent.; the thermometer then quickly rose to 230°, and between that temperature and 246°, 5 per cent. distilled. These fractions gave the following results:—

|                 |                                                                                                  |
|-----------------|--------------------------------------------------------------------------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.9001; rotation $\alpha_D + 15.7^\circ$ ; refractive index at 20° = 1.4613. |
| Second          | “ “ “ = 0.9165; rotation $\alpha_D + 6.4^\circ$ ; refractive index at 20° = 1.4616.              |
| Third           | “ “ “ = 0.9258; rotation not taken; refractive index at 20° = 1.4850.                            |

The cineol was determined by the resorcinol method in the oil distilling below 193°; the result was 63 per cent. when calculated for the crude oil. By the rapid phosphoric acid method it was 53 per cent. when calculated for the crude oil.

The saponification number for the esters and free acid was 18.3. In the cold with two hours' contact, it was 10.7, equal to 3.7 per cent. of geranyl-acetate when calculated for that ester.

A portion of the crude oil was rectified by steam. The product was almost colourless, and the odour good, whilst but little residue remained. The oil thus rectified had specific gravity at 15° C. = 0.9071; rotation  $\alpha_D + 12.1^\circ$ ; refractive index at 20° = 1.4621.

The results of this investigation were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

## 66. *Eucalyptus unialata*.

(R.T.B. & H.G.S., in Roy. Soc. Tas., 1912, p. 176, t. I.)

**Systematic.**—A tree reaching 30 to 40 feet in height, with a bark flaky at the butt and smooth above. Abnormal leaves sessile, the lower pairs oval, then cordate, acuminate, up to 3 inches long and  $1\frac{1}{2}$  inch wide to narrow lanceolate. Normal leaves lanceolate, falcate, up to 9 inches long and 1 inch wide, sub-coriaceous, occasionally shining on the upper surface; intramarginal vein slightly removed from the edge, venation distinct, lateral veins fairly oblique.



PLATE XXX



*R. T. Baker, del.*

**EUCALYPTUS UNIALATA, R.T.B. & H.G.S.**



no. 1000  
1000000000

Branchlets in seedling growth terete, but normally angular at first. Penduncles axillary, flattened, short, thick, 3 lines long, with three sessile flowers. Calyx tube compressed, angular, under 6 lines long; operculum conical.

**Fruit.**—Hemispherical, sometimes slightly flanged, shining generally with one rib; rim thickened, convex with a narrow groove below it; valves exserted; 5 lines long and 6 lines in diameter.



*These come somewhat closely in form to those of E. Muellieri or E. Baeuerleni.*

**Habitat.**—Mount Nelson, Tasmania.

**REMARKS.**—A particularly rare tree that has been classed with several others by systematists—by Mueller, as a form of *E. globulus*; Maiden, a form of *E. Maideni*, F.v.M. (Rodway, *Fl. Tas.*, p. 87). To us the facts point to its being worthy of distinctive rank.

**ESSENTIAL OIL.**—Material for distillation was collected near Hobart Tasmania, in August, 1912, and was quite fresh and green when received at the Museum. The yield of oil from the leaves and terminal branchlets was 0.89 per cent. The crude oil was light-amber in colour, and had an odour resembling that of the crude oil of *E. globulus*. It was fairly rich in cineol, and contained dextro-rotatory pinene; phellandrene was absent. The saponification number was somewhat high, and the oil contained rather a large amount of high-boiling constituents. The rectified oil had a distinctly yellow tinge.

The crude oil had specific gravity at 15° C. = 0.9179; rotation  $\alpha_D + 3.1^\circ$ ; refractive index at 20° = 1.4681, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. On the addition of about 10 volumes of this alcohol the oil became again turbid, indicating the presence of traces of the solid paraffin, a constituent which occurs in greater quantity in the oil of *E. acervula*. The saponification number for the esters and free acid was 11.1.

On rectification, a small amount of acid water and volatile aldehydes, having an objectionable odour, came over below 170° C. (corr.). Between 170–193°, 83 per cent. distilled, and between 193–268°, 11 per cent. distilled, mostly above 260°. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9104; rotation  $\alpha_D + 4.3^\circ$ ; refractive index at 20° = 1.4623.

Second                   "                   "                   = 0.9294; rotation not taken; refractive index at 20° = 1.4900.

The cineol was determined in the first fraction by the resorcinol method; the result was 62 per cent. when calculated for the crude oil. By the rapid phosphoric acid method it was 54 per cent. in the crude oil. After acetylation the saponification number was 20, thus showing the presence of alcoholic bodies in the rectified portion.

The results of this investigation were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

## 67. *Eucalyptus Gullicki*, sp. nov.

**Systematic.**—A medium sized tree with a smoothish bark. Abnormal leaves lanceolate, rarely ovate, usually under 3 inches long, almost sessile, mucronate or acute, seldom obtuse, venation netted, oil glands prominent. Normal leaves lanceolate, falcate, under 5 inches long, strongly acuminate, more or less shining, coriaceous, margin thickened; venation not prominent in the older leaves, intramarginal vein not far removed from the edge, lateral veins numerous, nearly parallel, inclined at an angle of 30–40° to the mid-rib. Peduncles axillary or lateral, angular, 2 to 4 lines long, each with an umbel of about five flowers. Buds almost sessile, somewhat shining, reddish. Calyx tube turbinate, 2 lines in length, and twice as long as the usually broad conical operculum, which sometimes shows a tendency to become acuminate.

**Fruit.**—Turbinate to hemispherical, contracted to a short pedicel; rim moderately broad, slightly domed or raised, depressed in the hemispherical shape, and concave when pyriform—the most common form; valves exerted; 2 lines long and 3 lines in diameter.

*The hemispherical fruits are uncommonly like those of E. hæmastoma and the pyriform ones with the concave raised rim (not sufficiently emphasised in the illustrations) and exerted valves, are most difficult to separate from those of E. Smithii, &c.*



**Habitat.**—This tree is fairly well distributed over the Blue Mountains, N.S.W.

**REMARKS.**—In the past it has probably been confounded with such species as *E. Smithii*, R.T.B., and when the fruits are immature with *E. maculosa*, R.T.B., or *E. hæmastoma*, Sm. var. *micrantha*, Benth., the two latter of which it much resembles in field characters, and even somewhat in fruits. From *E. maculosa*, R.T.B., it differs in the shape of the abnormal leaves and fruits, as well as chemical properties of the oil. From *E. hæmastoma*, Sm. var. *micrantha*, in the texture and venation of the leaves, the rim, shape of fruits, and disposition of the valves, and also in the absence of insect markings on the bark. From *E. Smithii*, R.T.B., in the nature of the bark, which is smooth like all other "Gums," whilst *E. Smithii* has a bark of an "Ironbark" character, and a timber much harder and pale than this species, whilst its botanical affinities are with most of the above enumerated species, yet chemically it differs from them all in its oil constituents.

### Dedication :—

This *Eucalyptus* is named in honour of Mr. William Applegate Gullick, the Government Printer, Sydney, in acknowledgment of the valuable assistance rendered to us during the last twenty-five years, in the furtherance of our technical research work, towards the accomplishment of which he has always given us material help, both by advice and application of his technical knowledge. His assistance in the passage of our books through the press, and the aid thus given we most gratefully acknowledge.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Lawson, New South Wales, in August, 1919. The yield of oil was 0.38 per cent. The crude oil was dark coloured, and had a rank terpene-like odour. A small quantity of pinene was detected, but phellandrene was absent. Cineol was present in some quantity, as was also eudesmol. Esters were not pronounced, but phenols were present in fair amount.



The crude oil had specific gravity at 15° C. = 0.9285; rotation  $a_D + 6.7^\circ$ ; refractive index at 20° = 1.4717, and was soluble in 1.1 volume 70 per cent. alcohol. The saponification number for the esters and free acid was 4.6, and in the cold with two hours' contact 3.6.

On rectification 2 per cent. distilled below 172° C. (corr.). Between 172–193°, 64 per cent. distilled; between 193–275°, 9.5 per cent. came over, and between 275–294°, 21 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9169; rotation  $a_D + 3.75^\circ$ ; refractive index at 20° = 1.4619.

Second „ „ „ = 0.9251; rotation  $a_D + 3.8^\circ$ ; refractive index at 20° = 1.4700.

Third „ „ „ = 0.9582; rotation not taken; refractive index at 20° = 1.5030.

The cineol was determined by the resorcinol method in the first fraction; the result was 56 per cent. when calculated for the crude oil. By the rapid phosphoric acid method it was 46 per cent. when calculated for the crude oil.

A portion of the oil was acetylated in the usual way; the saponification number had then risen to 67.2, and in the cold with two hours' contact it was 19.7. This result indicated that 19 per cent. of eudesmol and 4.4 per cent. of geraniol were present in the free condition. The eudesmol was purified, when it melted at 80° C., and in chloroform at 24° C., had specific rotation  $[a]_D + 33.65^\circ$ .

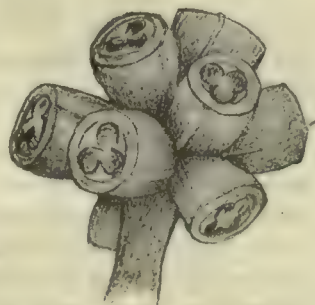
## 68. *Eucalyptus platypus*.

(Hook., Ic. Pl. t. 849, 1852.)

**Systematic.**—A small tree with a smooth bark. Abnormal leaves ovate or obcordate. Normal leaves broadly ovate or orbicular, often crenate, mostly under 2 inches long, thick, smooth and shining; venation not prominent. Peduncles axillary, thick, woody, flat, up to 6 lines broad and 2 inches long; bearing about five to twelve flowers. Calyx tube 3 to 4 lines long, narrow turbinate, sometimes ridged, sessile; operculum conical, obtuse, much longer and narrower than the calyx tube.

**Fruit.**—Crowded in heads, semi-ovoid or turbinate, slightly contracted at the orifice, ribbed; rim thick and slightly convex; valves often acuminate, exserted; 6 to 9 lines long, 4 to 7 lines in diameter.

*This clustering of fruits occurs also in E. Lehmanni and E. cornuta, but these latter are easily distinguished from this Eucalypt by their elongated valves.*



**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—The oil of this species was distilled by Mr. P. R. H. St. John, at Melbourne, September, 1919, from cultivated trees in the Botanic Gardens of that city, and forwarded to us for investigation. The yield of oil was 0.82 per cent. The crude oil was but little coloured, and had an odour similar to those of the cineol-pinene oils generally, although the volatile aldehydes were rather pronounced. The constituents present were dextro-rotatory pinene, cineol, esters, alcoholic bodies, and a little sesquiterpene. Phellandrene was not present, nor was it expected to occur in oils of this group.

The crude oil had specific gravity at 15° C. = 0.9103; rotation  $a_D + 10.2^\circ$ , refractive index at 20° = 1.4639; and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 15.2, and in the cold with 2 hours' contact 2.8. After acetylation it was 49.5, and in the cold 37.6. This result represents 9.6 per cent. free alcohols, having the  $C_{10}H_{18}O$  molecule.

On rectification, 2 per cent. distilled below 156° C. (corr.). Between 156–172°, 31 per cent. distilled; between 172–193°, 59 per cent. came over; between 193–217°, 5 per cent. distilled, and between 217–235°, 2 per cent. The fractions gave the following results:—

|                 |                                                                                             |
|-----------------|---------------------------------------------------------------------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8950; rotation $a_D + 16.2^\circ$ ; refractive index at 20° = 1.4601. |
| Second          | „ „ = 0.9123; rotation $a_D + 8.7^\circ$ ; refractive index at 20° = 1.4629.                |
| Third           | „ „ = 0.9350; rotation $a_D - 1.2^\circ$ ; refractive index at 20° = 1.4731.                |
| Fourth          | „ „ = 0.9385; rotation too dark; refractive index at 20° = 1.4811.                          |

The cineol was determined by the resorcinol method in the portion distilling between 156–193°; when calculated for the original oil the result was 63 per cent. By the phosphoric acid method, determined in the crude oil, it was 48 per cent. It is thus apparent that constituents other than cineol were absorbed by the resorcinol.

A similar alcohol to that in the oil of *E. longicornis* was present, and altogether the results with the oils of the two species were in close agreement.

A later distillation with material of this species was made by Mr. St. John, with the result that this oil was quite similar in character with the above, and did not contain phellandrene.

(For a determination of the oil of this species see Proc. Roy. Soc., Victoria, Vol. 28, 1915, by Mr. J. C. Earl.)

## 69. *Eucalyptus calycogona*.

(Turcz. Bull. Phys.-Math. Acad., Petersb., 10, p. 338, 1852.)

Gooseberry Mallee.

**Systematic.**—A “Mallee” growing in wetter situations than generally obtains in this class of Eucalypts (W. Gill). Abnormal leaves sometimes alternate, or shortly petiolate, sessile, narrow, elliptical or lanceolate, mucronate, about 1 inch long. Normal leaves lanceolate, thick, acuminate, hooked, shining, about 3 inches long and  $\frac{1}{2}$  inch wide; intramarginal vein parallel to and shortly removed from the edge, venation not prominent. Flowers in axillary umbels, common peduncle about 3 lines long. Buds about 7 lines long, covered with oil glands;



calyx tube almost sessile, prominently ribbed, tetragonal, tapering gradually to the base; operculum smooth, conical, reddish in colour, about one-third as long as the calyx tube.

**Fruit.**—Urn shape is perhaps the nearest term that describes the form, four to five prominent raised ribs giving it an angular appearance, shining; rim thin, circular; valves deeply inserted; about 5 lines long and 3 lines wide.



*These fruits are so nearly in shape to those of E. ochrophloia that it is just possible this may eventually prove to be the southern form of that species.*

**Habitat.**—Victoria, South Australia, Western Australia.

**REMARKS.**—At the writing of our first edition, this species had not been placed by us nor was the oil at that time obtainable. Recently, Mr. Walter Gill supplied material for this investigation, and so its systematic position now presents no difficulty.

PLATE XXXI.



Photo]

**EUCALYPTUS CALYCOGONA, TURCZ.**

[Walter Gill.

GOOSEBERRY MALLEE.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were forwarded by Mr. Walter Gill, the Conservator of Forests, South Australia. The material was collected at the Parilla Forest Reserve, South Australia, in October, 1919. The yield of oil was 1 per cent.

The crude oil was of an orange-brown colour, and had an odour similar to those of the cineol-pinene group; volatile aldehydes were not pronounced. The constituents present were dextro-rotatory pinene, cineol, alcoholic bodies, esters and some sesquiterpene. Phellandrene was not present.

The crude oil had specific gravity at 15° C. = 0.9152; rotation  $\alpha_D + 7.6^\circ$ ; refractive index at 20° = 1.4659, and was soluble in 5 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 7.3. After



acetylation it was 36.3, and 28.5 in the cold with 2 hours' contact. This result represents 8 per cent. of free alcohols calculated for the  $C_{10}H_{18}O$  molecule.

On rectification, 1 per cent. distilled below  $161^{\circ}C.$  (corr.). Between  $161-171^{\circ}$ , 30 per cent. distilled; between  $171-193^{\circ}$ , 54 per cent. came over; between  $193-225^{\circ}$ , 5 per cent. distilled, and between  $225-267^{\circ}$ , 8 per cent. These fractions gave the following results:—

|                 |                           |                                                                                       |
|-----------------|---------------------------|---------------------------------------------------------------------------------------|
| First fraction, | sp. gr. at $15^{\circ}C.$ | = 0.8999; rotation $a_D + 15.6^{\circ}$ ; refractive index at $20^{\circ} = 1.4604$ . |
| Second          | „ „                       | = 0.9137; rotation $a_D + 7.5^{\circ}$ ; refractive index at $20^{\circ} = 1.4617$ .  |
| Third           | „ „                       | = 0.9305; rotation $a_D - 5.0^{\circ}$ ; refractive index at $20^{\circ} = 1.4694$ .  |
| Fourth          | „ „                       | = 0.9450; rotation too dark; refractive index at $20^{\circ} = 1.4925$ .              |

The cineol was determined by the resorcinol method in the portion distilling below  $193^{\circ}C.$ ; when calculated for the original oil, the result was 55 per cent. By the phosphoric acid method it was 50 per cent., thus indicating but a small proportion of absorbable bodies, other than cineol, in the oil distilling below  $193^{\circ}$ .

## 70. *Eucalyptus Dalrympleana*.

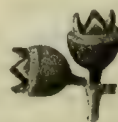
(J.H.M., in Forest Flora, N.S.W., Vol. VII, pt. 4.)

### A Mountain or White Gum.

**Systematic.**—A large tree up to 30 feet in girth, with a smooth bark, white in spring, and later becoming red, the whole trunk having a blotched appearance. Abnormal leaves scabrous when young, cordate to orbicular or ovate, stem clasping, sessile or very shortly petiolate, often mucronate, averaging 2 inches long and 2 inches broad. Normal leaves lanceolate, sometimes falcate, usually over 4 inches long and 9 lines wide; venation fairly prominent, intramarginal vein not far removed from the edge, lateral veins distant, more or less parallel, inclined at an angle of  $35-40^{\circ}$  to the mid-rib. Peduncles usually axillary, somewhat flattened, 3 lines long, each with an umbel of three flowers. Buds shortly pedicellate; calyx tube cylindroid,  $1\frac{1}{2}$  lines long; operculum semi-ovoid, as long or slightly longer than the tube.

**Fruit.**—Semi-ovoid, almost sessile; rim domed; valves thick, well exerted; 3 lines long and 3 lines in diameter.

*They are uncommonly like E. viminalis, so that these two cannot be separated by the fruit alone.*



**Habitat.**—Yarrangobilly, Batlow, Tumbarumba and mountainous country of south-east New South Wales; probably extending into Gippsland, Victoria.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were procured from Laurel Hill, near Batlow, New South Wales, in May, 1916. The material consisted wholly of the mature lanceolate leaves. The yield of oil was 0.15 per cent. The crude oil was of an amber colour, and had an odour similar to those of the cineol-pinene group generally. Cineol was present in some quantity. The chief terpene was pinene, and phellandrene was absent. A small quantity of the sesquiterpene was detected, but esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.9145; rotation  $a_D + 4.6^\circ$ ; refractive index at 20° = 1.4645, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.5.

On rectification 2 per cent. distilled below 162° C. (corr.). Between 162–172°, 27 per cent. distilled; between 172–192°, 60 per cent. came over, leaving 11 per cent. as residue. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9085; rotation  $a_D + 7.2^\circ$ ; refractive index at 20° = 1.4616.

Second                    „                    „                    = 0.9149; rotation  $a_D + 3.6^\circ$ ; refractive index at 20° = 1.4630.

The cineol, determined by the phosphoric acid method in the crude oil, was 50 per cent.

In March, 1899, material for distillation was received from Bungendore, New South Wales. The trees from which it had been collected bore some resemblance to *E. rubida*, but as the results did not agree with those for that species, the data we obtained were omitted in the first edition of this work. Now that the same tree has been located at Laurel Hill, and named, the previous results fall into line, and are here recorded. It is thus seen that *E. Dalrympleana* has quite an extensive range. The material consisted largely of abnormal leaves, consequently the yield of oil was larger than with the above, which was distilled from normal leaves, otherwise the oil was quite in agreement with it in all respects.

The yield of oil was 0.8 per cent. The crude oil had specific gravity at 15° C. = 0.9133; rotation  $a_D + 6.7^\circ$ ; refractive index at 20° = 1.4639, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 7.8.

On rectification 2 per cent. distilled below 168° C. (corr.). Between 168–183°, 84 per cent. distilled; between 183–245°, 7 per cent. came over, and between 245–265°, 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9105; rotation  $a_D + 7.6^\circ$ .

Second                    „                    „                    = 0.9198;                    „                    + 1.9°.

Third                    „                    „                    = 0.9354;                    „                    not taken.

The cineol determined by the phosphoric acid method was 50 per cent. in the crude oil (O.M.).

It is thus seen that the oil of this species contains much more cineol than does that of *E. rubida*, and that phellandrene is absent, consequently it has a higher rotation to the right, and is much more soluble in alcohol.

## GROUP III.

### CLASS (b).

In this Group are placed the following EUCALYPTS yielding an oil consisting principally of cineol and pinene, in which the cineol exceeds 55 per cent. Phellandrene and aromadendral\* are absent.

NOTE.—55 per cent. of cineol is the standard fixed by the British Pharmacopœia. The American Pharmacopœia demands 70 per cent. cineol. See also Group IV, class (a).

- |     |                                |
|-----|--------------------------------|
| 71. | <i>Eucalyptus sideroxylon.</i> |
| 72. | <i>E. squamosa.</i>            |
| 73. | <i>E. Smithii.</i>             |
| 74. | <i>E. Bridgesiana.</i>         |
| 75. | <i>E. populifolia.</i>         |
| 76. | <i>E. Parramattensis.</i>      |
| 77. | <i>E. parvifolia.</i>          |
| 78. | <i>E. pumila.</i>              |
| 79. | <i>E. pulverulenta.</i>        |
| 80. | <i>E. Morrisii.</i>            |
| 81. | <i>E. Moorei.</i>              |
| 82. | <i>E. Muelleri.</i>            |
| 83. | <i>E. longicornis.</i>         |
| 84. | <i>E. Perriniana.</i>          |
| 85. | <i>E. costata.</i>             |
| 86. | <i>E. maculosa.</i>            |
| 87. | <i>E. goniocalyx.</i>          |
| 88. | <i>E. globulus.</i>            |
| 89. | <i>E. Nepeanensis.</i>         |
| 90. | <i>E. cordata.</i>             |
| 91. | <i>E. Australiana.</i>         |

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\*The name Aromadendral is used throughout this work in a general sense to denote the presence of one or more members of this group of characteristic aldehydes, which includes cuminaldehyde and cryptal. See the article in this work on these aldehydes.



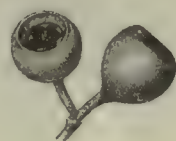
## 71. *Eucalyptus sideroxylon*.

(A. Cunn., in Mitch. Trop. Aust., 339, name only.)

**Red Flowering Ironbark.**

**Systematic.**—A tree occasionally as high as 100 feet. Bark persistent, rough, black, very deeply furrowed. Abnormal leaves similar in shape to the normal ones, only slightly smaller. Normal leaves lanceolate, slightly falcate, under 6 inches long; venation indistinct, lateral veins fine, spreading, intramarginal vein removed from the edge. Penducles slender, axillary, about 1 inch long. Flowers fairly large, about six in the umbel, mostly red but occasionally white. Calyx about 3 lines long, elongated, on a slender pedicel from 3 to 4 lines long, 3 lines in diameter; operculum equal in length to the calyx, conical, obtuse.

**Fruit.**—Globular, truncate, contracted at the edge, the pedicel lengthening after flowering; rim concave after the removal of the primary one, which becomes detached when the capsule ripens, this latter feature readily distinguishes the fruits from most other species; valves inserted; 4 lines in diameter.



*A deciduous secondary rim is found only in this and in a few other species, such as E. leucoxyton, E. caerulea, and sometimes E. melliodora.*

**Habitat.**—Coast district of New South Wales, Queensland and Victoria.

**REMARKS.**—Cunningham's name of *E. sideroxylon* is retained for this tree, which was first mentioned in Mitchell's "Tropical Australia," p. 339. To Dr. Woolls (Proc. Linn. Soc., N.S.W., p. 856) is due the credit of proving conclusively that both Mueller and Bentham included two distinct trees under the name of *E. leucoxyton*, i.e., the South Australian "White Gum" and this "Red-flowering Ironbark." They differ in bark, timber, flowers, fruits and anthers, and probably chemical constituents. This Ironbark is very constant in specific characters throughout its extensive range in New South Wales and Victoria. The colour of the flowers, however, vary from cream to light pink. The bark is also black and friable.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Liverpool, N.S.W., in December, 1900. The yield of oil was 0.75 per cent. The crude oil was of a reddish-yellow colour, and had an odour resembling the cineol-pinene class of Eucalyptus oils. The usual amount of volatile aldehydes for oils of this group was present. The oil was rich in cineol; pinene was present, but phellandrene was absent. An aldehyde was present in the higher boiling fraction, together with the sesquiterpene. The rectified oil was of good quality for a cineol oil, and was slightly coloured yellow, a character traceable to the influence of the phenols. In general characters the oil was not in entire agreement with those of the "Ironbarks" generally.

This species has been worked for its oil to some extent in the Bendigo District of Victoria, where the yield usually exceeds 1 per cent.

The crude oil had specific gravity at 15° C. = 0.9227; rotation  $\alpha_D + 1.9^\circ$ , refractive index at 20° = 1.4668, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.5.

On rectification, 1 per cent. distilled below  $162^{\circ}$  C. (corr.). Between  $162-183^{\circ}$ , 91 per cent. distilled; between  $183-240^{\circ}$ , only a few drops came over, and between  $240-255^{\circ}$ , 3 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. =  $0.9193$ ; rotation  $a_D + 1.93^{\circ}$ .

Second " " " " " =  $0.9370$ ; " " " " " not taken.

The cineol, determined by the phosphoric acid method in the rectified portion, gave 66 per cent. of that constituent, indicating about 60 per cent. in the crude oil (O.M.).

Material of this species for distillation was also obtained from Condobolin, N.S.W., in March, 1901. The oil was practically identical with that distilled from the Liverpool trees, and contained the same constituents in practically the same amounts. The yield of oil was 0.51 per cent. The specific gravity of the crude oil was  $0.9189$ , and the optical rotation  $a_D + 3.2^{\circ}$ . The cineol determined by the phosphoric acid method in the crude oil was 57 per cent. (O.M.).

Material for distillation was also obtained from Narrabri, N.S.W., in July, 1901. The oil was practically identical with the above samples, contained similar constituents in agreeing amounts, and was equally rich in cineol. The yield of oil was 0.49 per cent. The specific gravity of the crude oil was  $0.9201$ , and optical rotation  $a_D + 1.4^{\circ}$ . The cineol, determined by the phosphoric acid method in the crude oil, was 58 per cent. (O.M.). The crude oil was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol.

It will be seen from these results that the oil of this species shows a constancy in composition wherever the trees are growing, and is thus a well stabilised species.

In the samples recorded above, the oils were distilled from normal leaves of old trees, and the yields of oil are consequently less than would be obtained from young material or from leaves of abnormal growth. This is a peculiarity shown with many species of Eucalypts, and numerous instances of this are given in this work.

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. Not much alteration had taken place during the 20 years the oil had been kept, with the exception that the cineol had increased a little in amount. The crude oil and the rectified portion gave the following results:—90 per cent. distilled below  $190^{\circ}$  C.

Crude oil, sp. gr. at  $15^{\circ}$  C. =  $0.9238$ ; rotation  $a_D + 2.8^{\circ}$ ; refractive index at  $20^{\circ}$  =  $1.4637$ .

Rectified portion " " " " " =  $0.9207$ ; rotation  $a_D + 2.6^{\circ}$ ; refractive index at  $20^{\circ}$  =  $1.4608$ .

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 78 per cent. By the rapid phosphoric acid method it was 65 per cent. when calculated for the crude oil. Terpeneol was detected in the rectified portion.





EUCALYPTUS SIDEROXYLON, A. CUNN.  
RED FLOWERING IRONBARK.



no. 1000  
1000000000

## 72. *Eucalyptus squamosa*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1897, p. 561, t. XIX.)

Ironwood.

**Systematic.**—A fair sized tree, with a scaly or smoothish bark, somewhat resembling that of *E. punctata*. Abnormal leaves ovate, and finally ovate-lanceolate. Normal leaves narrow to rather broad-lanceolate, or ovate-lanceolate, slightly falcate,  $3\frac{1}{2}$  to nearly 6 inches long, pale green to glaucous, the surface glandular punctate; intramarginal vein very near the edge, transverse veins numerous and fine. Peduncles roundish, not flattened, nor angular, frequently or usually in pairs. The flowers generally from eight to twelve in the umbel. Calyx tube sub-cylindrical, almost ovate, somewhat urceolate in young fruit; operculum ovate, but more or less pointed or beaked, and frequently showing a marked curve to one side. The length of the operculum about equal to that of the calyx, viz., about 3 lines.

**Fruit.**—Nearly hemispherical, with a slight tendency to constriction at the orifice; rim inclined to be countersunk; valves 3 or 4 and slightly exserted; about 4 lines broad by 3 lines long.



*Although there is nothing particularly characteristic about the fruit yet when once known it is not easily mistaken for any other.*

**Habitat.**—On sterile sandstone ridges in the county of Cumberland, National Park, Putty, Kelgoola, near Rylstone, St. Marys, New South Wales.

**REMARKS.**—Its most obvious characteristic is its scaly bark. Another good characteristic of the species is the curved operculum of the buds, which seems to obtain wherever the species occurs.

**ESSENTIAL OIL.**—Leaves and branchlets for distillation were obtained from National Park, near Sydney, N.S.W., in September, 1900. The yield of oil was 0.65 per cent. The oil was but slightly coloured, and had an odour resembling those of the cineol-pinene group. Volatile aldehydes were present in some quantity. It contained much cineol, some pinene, and a trace of phellandrene, although at other times this constituent appeared to be absent. A small quantity of aromadendral was detected, and consequently the second fraction had a slight lævo-rotation.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9182; rotation nil; refractive index at  $20^{\circ}$  = 1.4635, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.5.

On rectification 2 per cent. distilled below  $167^{\circ}$  C. (corr.). Between  $167$ – $183^{\circ}$ , 80 per cent. distilled, and between  $183$ – $247^{\circ}$ , 10 per cent. came over.

The large fraction had specific gravity at  $15^{\circ}$  = 0.9161; rotation  $\alpha_D + 0.8^{\circ}$ . The second fraction had specific gravity at  $15^{\circ}$  = 0.9278; rotation not taken. The cineol, determined in the large fraction by the phosphoric acid method, was 60 per cent., indicating about 51 per cent. in the crude oil (O.M.).

In the year 1900 this species was worked commercially for its oil at Nelson, near Riverstone, N.S.W. The oil obtained was practically identical with the above, and the crude oil contained 61 per cent. of cineol determined by the phosphoric acid method (O.M.).

Another sample distilled at the end of the year 1900 also gave similar results.

The above oils were mixed together and preserved in the dark, and in September, 1919, nineteen years afterwards, this oil was again analysed. Not much alteration was observed, except that it was a little heavier and contained more cineol. 90 per cent. distilled below 190°. The crude oil and the large fraction gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9386; rotation  $a_D + 1.6^\circ$ ; refractive index at 20° = 1.4640.

Large fraction „ „ = 0.9258; rotation  $a_D + 2.25^\circ$ ; refractive index at 20° = 1.4597.

The cineol was determined by the resorcinol method in the large fraction, and calculated for the crude oil; the result was 81 per cent. By the rapid phosphoric acid method it was 70 per cent., when calculated for the original oil.

### 73. *Eucalyptus Smithii*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1899, p. 292, t. XX).

**White Top, Gully Ash, White Ironbark.**

**Systematic.**—A tall tree, sometimes attaining a height of 150 feet, and a diameter from 2 to 5 feet. Bark of young trees has a strong resemblance to that of *E. radiata*, on old trees deeply furrowed, and in colour dark grey to blackish up to the branches, similar to that of the "Mountain Ash" (*E. Sieberiana*, F.v.M.) or an "Ironbark," smooth to the branchlets. Abnormal leaves sessile, resembling those of *E. Australiana*, *E. phellandra*, or *E. radiata*, lanceolate-cordate, 5 to 6 inches long, not glaucous. Normal leaves narrow-lanceolate, acuminate, of an equal colour on both sides, not shining; venation distinct and characteristic of cineol-pinene oil-yielding leaves, lateral veins fine, numerous, spreading, intramarginal vein slightly removed from the edge; petiole about 1 inch long. Oil-glands very numerous. Peduncles axillary, flattened, about as long as the petiole, with numerous flowers, from three to fifteen. Calyx turbinate, narrowing into a short pedicel, the whole 3 to 4 lines long; operculum hemispherical, shortly acuminate.

**Fruit.**—Shortly pedicellate, hemispherical, inclining occasionally to pyriform; rim raised, concave; valves well exerted and expanding, obtuse; 2 to 3 lines in diameter.

*Care is required to differentiate it from E. viminalis, E. maculosa, and especially E. Gullicki, sp. nov. In some cases in the early and smaller fruits the rim is only slightly concave.*



**Habitat.**—New South Wales Coast district, south from Mittagong, also Sugarloaf Mountain, Monga, and Irish Corner Mountain, Braidwood, Hill Top, Wingecaribbee, Sutton Forest, Nandi, extending into Victoria.





*EUCALYPTUS SMITHII*, R.T.B.  
WHITE TOP OR GULLY ASH.

no. 1000  
1000.0000

**REMARKS.**—It attains a large size in suitable situations, and on the Nandi-road, Moss Vale, trees are found up to 14 feet in circumference, with bark exceedingly thick and deeply furrowed, strongly resembling in this feature that of some "Ironbarks" as *E. crebra*. In the medium and early stages of its growth the bark is somewhat smooth. The timber is pale-coloured, close-grained, hard, and difficult to work. It has been cut largely for works of construction in the Wingello district. In the field it is easy to confound it with *E. Sieberiana* on a cortical classification, and in the herbarium with *E. Australiana*, the abnormal leaves having a great resemblance to that species, as they also do to *E. viminalis*. The peculiar structure of its deeply furrowed bark distinguishes it from any of its congeners, particularly *E. viminalis*, Labill., which has not a thick, furrowed bark, traversed radially by broad rays of a yellow, pith-like substance, not possessing the characteristic odour so marked in this species.

PLATE XXXIV.



M. F. Connelly, Photo.]

**EUCALYPTUS SMITHII. R.T.B.**

"GULLY ASH" OR "WHITE TOP."

Characteristic appearance of this Eucalypt as it grows in the gullies. Nearly the whole of the trees shown belong to this species. The figure at the base of the centre tree gives the comparative heights.

WINGELLO, N.S.W.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Sugar-loaf Mountain, Monga, near Braidwood, N.S.W., in September, 1898. The yield of oil was 1.4 per cent. The crude oil was light reddish



yellow in colour, and had an odour resembling those of the cineol-pinene oils generally. Volatile aldehydes were present, but only in small amount, and the esters were also in a minimum quantity. The oil was exceedingly rich in cineol. Pinene was the principal terpene, and phellandrene was absent. Only a small amount of constituents having a high-boiling point (aromadendrene, &c.) was present, and 96 per cent. of the crude oil distilled below  $183^{\circ}\text{C}$ ., consequently the specific gravity was comparatively low for an oil so rich in cineol. The oil of this species is one of the best of the whole group for the distillation of a rich cineol bearing Eucalyptus oil. Crystallised eudesmol in small amount was present, although in that from the abnormal leaves it was difficult to detect. A solid paraffin was also present.

The crude oil had specific gravity at  $15^{\circ}\text{C}$ . = 0.915; rotation  $a_D + 6.15^{\circ}$ ; refractive index at  $20^{\circ}\text{C}$ . = 1.4649, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.4.

On rectification 1 per cent. distilled below  $168^{\circ}\text{C}$ . (corr.). Between  $168$ – $173^{\circ}$ , 64 per cent. distilled; between  $173$ – $183^{\circ}$ , 31 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C}$ . = 0.911; rotation  $a_D + 7.0^{\circ}$ .

Second " " " " = 0.914; " " +  $4.14^{\circ}$ .

The cineol, determined by the phosphoric acid method in the crude oil, was 70 per cent. (O.M.).

Material for distillation was also obtained from Irish Corner Mountain, Monga, N.S.W., in September, 1898. This second consignment was received in order to test the constancy of results as regards the oil of this species. The yield of oil was 1.6 per cent. The colour, odour, and constituents differed in no respect from those of the previous sample, and 96 per cent. distilled below  $183^{\circ}\text{C}$ . By tabulating the results it is seen how closely the oils agree in general characters, the fractions and percentages being practically identical with each. Both oils were equally rich in cineol.

|                             | Specific Gravity at $15^{\circ}\text{C}$ . Crude Oil. | Specific Gravity at $15^{\circ}\text{C}$ . First Fraction. | Specific Gravity at $15^{\circ}\text{C}$ . Second Fraction. | Optical Rotation Crude Oil. $a_D$ | Optical Rotation First Fraction $a_D$ | Optical Rotation Sec. Fraction $a_D$ |
|-----------------------------|-------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------|---------------------------------------|--------------------------------------|
| E. Smithii, Monga, 5-9-88.  | 0.915                                                 | 0.9110                                                     | 0.914                                                       | + $6.15^{\circ}$                  | + $7.0^{\circ}$                       | + $4.14^{\circ}$                     |
| E. Smithii, Monga, 28-9-88. | 0.915                                                 | 0.9107                                                     | 0.913                                                       | + $6.25^{\circ}$                  | + $7.2^{\circ}$                       | + $4.0^{\circ}$                      |

Material of this species for distillation was also obtained from Wingello, N.S.W., in April, 1900. The yield of oil was 1.14 per cent. The oil differed in no respect from the previous samples, and was equally rich in cineol. The specific gravity of the crude oil was 0.9158, and the optical rotation  $a_D + 4.9^{\circ}$ . The amount of esters was also in agreement.

Since that time much oil from this species has been distilled commercially, and all the samples we have tested have shown great uniformity, and evidently the species is one that has long been stabilised.

Material for distillation was also obtained from the abnormal leaves in order to test the value of the oil from this portion of the plant; the leaves were collected at Wingello, N.S.W., in February, 1901. The yield of oil was 1.8 per cent. In appearance, odour, and constituents, the oil was identical with that obtained from the mature leaves, with the exception that the pinene was a little higher and the cineol a little less in amount; but even then the oil formed a clear solution with  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The specific gravity of the crude oil was 0.9133, and the optical rotation  $a_D + 6.4^\circ$ . The saponification number for the esters and free acid was 3. Eudesmol was detected in small amount. It is thus evident that the oil from the leaves of this species may be profitably distilled, especially as the yield is large for an oil so rich in cineol. In other parts of this work it is demonstrated that plantations of this species could be utilised with advantage for Eucalyptus oil distillation, so that by systematic cultivation the difficulty of collecting the leaves from mature trees might be avoided.

When the whole of the factors in regard to the oil of this species are taken into consideration, it may be regarded as one of the best Eucalypts, so far determined, for the production of a rich cineol Eucalyptus oil. The following reasons in support of this statement may be advanced:—

1. The yield of oil from both abnormal and mature leaves is large.
2. The oil from both abnormal and mature leaves is practically of equal value.
3. The oil is very rich in cineol.
4. A relative absence of constituents of high-boiling point avoids much loss on rectification.
5. The comparative absence of esters and objectionable volatile aldehydes allows the rectified oil to be of superior quality.
6. The species lends itself to ready cultivation.

See also the article on "The Variation in the character of Eucalyptus Oils distilled from trees of differing ages and forms of growth."

## 74. *Eucalyptus Bridgesiana*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1898, p. 164, t. V).

Apple or Woolly-butt, Butt Butt of Gippsland (A. W. Howitt).

**Systematic.**—A tree of considerable size, grows to a great height, particularly in loamy soil. Bark whitish grey, wrinkled or tessellated, short and brittle in the grain, not fibrous, almost identical with that of the "Boxes," and when freshly cut exhales an aroma similar to the ordinary oil obtained from Eucalyptus leaves. Abnormal leaves in the early stage ovate-cordate, and then ovate-acuminate, petiolate or sessile, opposite or alternate. Normal leaves on rather long petioles, lanceolate, acuminate, often falcate, varying in length to over 1 foot, not shining, the southern form drying a light grey colour, the northern a darkish green; lateral veins either prominent or faint, spreading, the



intramarginal one well removed from the edge. Umbels capitate, axillary, on flattened peduncles, bearing about seven flowers; pedicels from 1 to 3 or 4 lines long; tube of the calyx semi-ovate, rarely top-shaped; operculum hemispherical, obtuse or acuminate.

**Fruit.**—Hemispherical, rarely conical, on a short or long pedicel; rim mostly thickened with a ring below the edge; a specimen from Araluen has quite a flange; valves exserted; 3 to 4 lines in diameter.

*The fruits are characteristic; they somewhat resemble E. resinifera or occasionally E. viminalis, but the rim is more domed.*

**Habitat.**—Southern half of Dividing Range, New South Wales, into Gippsland, Victoria.



**REMARKS.**—Objections have been taken (*vide* Proc. Linn. Soc., New South Wales, 1899, Part IV, p. 628) to the specific rank of this species, and efforts made to show that it is identical with Baron Mueller's *E. Stuartiana*, the "Apple" of Victoria. We contend that *E. Stuartiana*, F.v.M., does not appear to occur in this State, as Mueller's description in the *Eucalyptographia* applies to the "Apple tree" of Victoria, which has a red, almost Stringy-bark and a red-coloured timber. As stated by Mueller, "*Argyle Apple*" (*E. cinerea*, F.v.M.), is distinguished from *E. Stuartiana* only in foliage. . . . The bark of *E. Stuartiana* and *E. cinerea*, F.v.M., are very much alike." Such statements can only apply to the Victorian Eucalypt and the "*Argyle Apple*," as these characters do not apply to *E. Bridgesiana*. Dr. Howitt, F.G.S., a co-worker with Mueller on the Eucalypts, and one who collected the original *E. Stuartiana* material for him, holds that it was the "Victorian Apple" on which Mueller founded *E. Stuartiana*, and this is substantiated by all the writings and herbarium material of the late Baron, and by those who, along with him, were familiar with the tree in the field at the time of the publication of his work on Eucalypts. Dr. Howitt was quite in accord with our classification of these two species—*E. Stuartiana* and *E. Bridgesiana*. The figure (*loc. cit.*) somewhat resembles *E. Bridgesiana*, R.T.B., which species has been confounded with *E. Stuartiana* when working on dried material and some fancied nuances. The prevailing foliage of *E. Stuartiana* is lanceolate, sessile. Since publishing the first edition no new data have come to hand to alter our original classification. *E. Bridgesiana* has a pale-coloured, compact, persistent, oil-yielding, "Box"-like bark, and a pale coloured timber; characters entirely wanting in the "Apple" of Victoria (*E. Stuartiana*), as verified in the description given in the *Eucalyptographia*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for oil distillation were obtained from Ilford, N.S.W., in February, 1898. The yield of oil was 0.57 per cent. The crude oil was of an orange-brown colour, and had an odour resembling those belonging to the cineol-pinene group. Pinene was present, but phellandrene was absent. The oil was rich in cineol. The higher boiling portion consisted largely of the sesquiterpene. The pinene was determined by its chemical reactions in the lower boiling portion. This Eucalypt gives one of the richest cineol oils of the group to which it belongs, but unfortunately the yield is not sufficiently large for it to be commercially profitable.

The crude oil had specific gravity at 15° C. = 0.9120; rotation  $a_D + 3.35^\circ$ ; refractive index at 20° = 1.4666, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 6.2.

On rectification 2 per cent. distilled below 169° C. (corr.), in which portion the volatile aldehydes were pronounced. Between 169–174°, 27 per cent. distilled; between 174–183°, 57 per cent. came over; between 183–255°, 4 per cent. distilled, and two more between 255–265°. These fractions gave the following results:—

|                 |                             |                               |
|-----------------|-----------------------------|-------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.9065; | rotation $a_D + 5.35^\circ$ . |
| Second          | " " " = 0.9128;             | " " $a_D + 2.70^\circ$ .      |
| Third           | " " " = 0.9136;             | " " not taken.                |

Another sample of the same oil was separated at 183°. This had specific gravity at 15° = 0.911, and rotation  $a_D + 3.4^\circ$ .

The cineol, determined by the phosphoric acid method in the portion distilling below 183° was 65 per cent., indicating about 58 per cent. in the crude oil (O.M.).





R.T.B., del.

EUCALYPTUS BRIDGESIANA, R.T.B.  
WOOLLY BUTT.

UNIV. OF  
CALIFORNIA

30 vol  
1000000000

The mixed oil of this species was preserved in the dark, and in September, 1919, twenty-one years afterwards, was again analysed. Not much alteration had taken place in the oil during that period, except that the cineol had apparently increased, and consequently the specific gravity also. 90 per cent. of the oil distilled below 190° C. The crude oil and the large fraction gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9383; rotation  $a_D + 4.4^\circ$ ; refractive index at 20° = 1.4667.

Large fraction           ,,           ,,           = 0.9220; rotation  $a_D + 3.5^\circ$ ; refractive index at 20° = 1.4599.

The cineol was determined in the large fraction by the resorcinol method and calculated for the crude oil; the result was 81 per cent. By the phosphoric acid method it was 79 per cent. when calculated for the crude oil.

Material of this species was also obtained from Bungendore, N.S.W., in June, 1898. The oil differed but slightly from that obtained from Ilford, with the exception that the specific gravity was somewhat higher. Considering the difference in the time of year this was to be expected, as the present sample was distilled in midwinter. The yield of oil was 0.68 per cent. It was rich in cineol and free from phellandrene.

Leaves of this species, the "Butt-butt," of Gippsland, Victoria, were received from Mr. A. W. Howitt, F.G.S., in July, 1898. The oil from this material differed in no respect from the above samples; was equally rich in cineol, contained pinene, and phellandrene was absent. The yield of oil was 0.58 per cent.

Later, in September, 1899, we received material of this species for distillation from Mr. J. F. Campbell, who obtained it at Walcha, N.S.W. It had been collected as would be done for commercial distillation. The crude oil was of an orange-yellow colour, and had an odour characteristic of oils belonging to the cineol-pinene class. Cineol was the principal constituent; it also contained some pinene, but phellandrene was absent. The higher boiling portion consisted largely of the sesquiterpene. The ester was small in amount, similar to the other oils of this species so far tested. The rectified oil was slightly tinged yellow, a character common with the rich cineol oils belonging to this class.

In April, 1908, material of this species was sent from Woolbrook, N.S.W., by the Museum collector. The oil distilled from this was identical with that from material sent from Walcha many years previously.

The following results were obtained with the crude oils from these two localities:—

|                                                                                               | Walcha.<br>18th September, 1899. | Woolbrook.<br>8th April, 1908. |
|-----------------------------------------------------------------------------------------------|----------------------------------|--------------------------------|
| Yield of oil, per cent. ... ..                                                                | =0.73                            | =0.74                          |
| Specific gravity at 15° C. ... ..                                                             | =0.9223                          | =0.9246                        |
| Rotation $a_D$ ... ..                                                                         | + 1.9°                           | + 1.8°                         |
| Refractive index at 20° C. ... ..                                                             | =1.4655                          | =1.4672                        |
| Saponification number for ester and free acid ... ..                                          | =8.7                             | =7.6                           |
| Cineol determined by the phosphoric acid method in<br>portion distilling below 183° C. ... .. | =73 per cent.                    | =78 per cent.                  |



On rectifying the Walcha sample the amount distilling between  $172-183^{\circ}$  was 77 per cent.; between  $183-245^{\circ}$ , 11 per cent.; and between  $245-265^{\circ}$ , 5 per cent. As seen above the first fractions consisted very largely of cineol, with some dextro-rotatory pinene.

Another portion of the crude oil of the Walcha sample was rectified by steam. The product was tinged yellow (a character common to the oils of this class), had a good odour and consisted largely of cineol. It had specific gravity at  $15^{\circ}\text{C.} = 0.9203$ ; rotation  $\alpha_D + 3.1^{\circ}$ ; refractive index at  $20^{\circ} = 1.4606$ , and was soluble in 1.1 volumes 70 per cent. alcohol.

#### OIL FROM THE BARK OF THIS SPECIES.

This bark has an aromatic odour when fresh, so much so, that it was thought it might be possible to obtain an oil from it.

Material was obtained from Ilford, N.S.W., in June, 1898, and the bark finely chopped and then crushed. Two distillations were made of the chopped and crushed bark, each of 80 lb. weight, which was steam distilled. A small quantity of oil was obtained, about 2 drachms altogether; such a small quantity was difficult to collect, but about 1 drachm of clear and filtered oil was obtained. The oil was red in colour; was very mobile, and gave no reaction for cineol. Phellandrene was absent. The specific gravity at  $15^{\circ}\text{C.} = 0.898$ . The appearance, odour, &c., of the oil suggested that it might contain an ester in some quantity, but the specimen being required for Museum purposes, further determinations were not made. It is thus apparent that the odour of the bark of this species is due to the presence of a volatile oil, and that this is essentially different in composition from the leaf oil. Although oil rarely occurs in the barks of the Eucalypts, yet it has been noticed in a few cases, particularly with that of *E. Macarthuri*. (See under that species.)

## 75. *Eucalyptus populifolia*.

(Hook., in Ic. Pl., t. 879, 1852.)

**Bimbil Box** or **Poplar-leaved Box**.

**Systematic.**—A medium-sized tree; bark persistent on the stem and branches, rough, not deeply furrowed, sometimes whitish or khaki coloured between a "Box" and a "Woollybutt" in character. Abnormal leaves oval to ovate-acuminate, 2 inches long, shining on both sides; venation distinct, lateral veins few, spreading, intramarginal vein removed from the edge. Normal leaves very variable in size and shape, from ovate-acuminate, ovate-lanceolate to narrow-lanceolate, under 6 inches long; venation and other features similar to that of abnormal leaves. Flowers numerous in axillary or terminal panicles, peduncles slender, under 6 lines long. Calyx turbinate, 1 line long and 1 line in diameter, also on a pedicel of about 1 line; operculum hemispherical, shortly acuminate.

**Fruit.**—Small, pear-shaped to slightly hemispherical; rim truncate; valves not exerted; under 2 lines long.

*They very closely resemble those of E. crebra and E. polybractea in form.*



**Habitat.**—The northern half of the Central Division of New South Wales; Queensland; North Australia.



R.T.B., del. ad nat.

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**EUCALYPTUS POPULIFOLIA, HOOK.**

POPLAR LEAF BOX.





**REMARKS.**—The shining "Poplar-leaved Box" was confounded by Bentham, B.Fl., iii, p. 214, with *E. polyanthemus* (probably including also *E. Fletcheri*, R.T.B., and *E. ovalifolia*, R.T.B.), but all these trees we regard as quite distinct, as they differ in the bark, timber, leaves, and chemical constituents. It occurs in the dry interior of the Continent, whilst the others above enumerated are confined to the Coast and tableland. Mueller figures this species in his *Eucalyptographia*, but it is again here delineated in order to show the variability of its foliage, which is not illustrated by Mueller (*loc. cit.*), and also on account of its being a good cineol-yielding species. The timber is hard, interlocked, and reddish in colour.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nyngan, N.S.W., in November, 1899. The yield of oil was 0.66 per cent. The crude oil was yellowish-brown in colour, and had an odour resembling those of the cineol-pinene class. Cineol was present in quantity, together with pinene, but phellandrene was absent. The higher boiling portion contained the sesquiterpene. The crude oil became turbid on keeping, and eventually deposited a sediment, as do many of the oils belonging to this class.

The crude oil had specific gravity at 15° C. = 0.9207; rotation  $a_D + 0.4^\circ$ ; refractive index at 20° = 1.4652, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 1.9.

On rectification, 2 per cent. distilled below 170° C. (corr.). Between 170–183°, 90 per cent. distilled; between 183–255°, only a few drops came over; between 255–265°, 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9177; rotation  $a_D + 5.96^\circ$ .

Second " " " = 0.9259; " not taken.

The cineol, determined by the phosphoric acid method in the crude oil, was 62 per cent. (O.M.)

The oil of this species is one of the best of the cineol-pinene group, but unfortunately the yield is not large.

Material from this species was received from Gunbar, N.S.W., in December, 1900. With the exception that the yield was rather larger, the oils were practically identical; both were heavy oils, rich in cineol, had slight rotation, showed the presence of pinene and absence of phellandrene. The yield of oil was 0.86 per cent. Specific gravity of the crude oil = 0.923; and optical rotation  $a_D + 1.2^\circ$ . The cineol was determined by the phosphoric acid method in the crude oil; the result was 57 per cent. (O.M.). The crude oil formed a clear solution with 1½ volumes 70 per cent. alcohol.

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. The alteration which had taken place in the oil during the nineteen years it had been kept, was in the direction of an increased cineol content; otherwise not much difference was observed. 86 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9352; rotation  $a_D + 0.4^\circ$ ; refractive index at 20° = 1.4656.

Rectified portion " " = 0.9227; rotation  $a_D + 1.4^\circ$ ; refractive index at 20° = 1.4602.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 77 per cent. By the rapid phosphoric acid method it was 70 per cent. when calculated for the original oil. Terpeneol was detected in the rectified portion.

## 76. *Eucalyptus Parramattensis*.

(Cuthbert Hall, Proc. Linn. Soc., N.S.W., 1912, p. 568.)

**Systematic.**—A medium sized tree, 30 feet in height, with a smooth, greyish, rather dirty bark. Abnormal leaves lanceolate, petiolate, thin, usually alternate, sometimes acuminate. Normal leaves lanceolate, smaller than the abnormal, often 7 inches long, acuminate, falcate, fairly thick; venation not very prominent, intramarginal vein not far from the edge, lateral veins fairly distant, inclined at an angle of  $45^\circ$  or more to the mid-rib. Peduncle axillary, 3 lines long, with umbels of four to seven flowers. Buds on pedicels 1 to 2 lines in length; calyx tube turbinate,  $1\frac{1}{2}$  lines long, about equal to the conoidal operculum. (Operculum much longer than the calyx tube.—C. Hall.)

**Fruit.**—Hemispherical; shortly pedicellate, more or less shining; rim convex; valves well exserted;  $2\frac{1}{2}$  lines long and 3 lines in diameter.



*At first glance they might be mistaken for E. dealbata, and then in similarity to E. resinifera, whilst perhaps the next nearest the flat-rim form of E. pumila.*

**Habitat.**—New South Wales, from Milton to Mudgee and Singleton.

**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were received from Fairfield, N.S.W., in May, 1911. The yield of oil was 0.57 per cent. The crude oil was but little coloured and had an odour resembling those of the cineol-pinene oils generally. Pinene was detected, but phellandrene was absent. Cineol was present in great quantity, and if the yield was greater the oil of this species would be one of the best of the cineol group for commercial distillation. The rectified oil was yellowish in tint, as is common with those of this class. The odour of the aldehydes, valeraldehyde and butaldehyde, was somewhat pronounced.

The crude oil had specific gravity at  $15^\circ\text{C.} = 0.9223$ ; rotation  $a_D + 2.7^\circ$ ; refractive index at  $20^\circ = 1.4629$ ; and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.6. The amount distilling below  $190^\circ\text{C.}$  was 89 per cent. The cineol was determined by the resorcinol method in the rectified portion, and when calculated for the crude oil the result was 78 per cent. By the rapid phosphoric acid method it was 75 per cent. in the crude oil.



## 77. *Eucalyptus parvifolia*.

(R.H.C., Proc. Linn. Soc., N.S.W., 1909, p. 336.)

**Systematic.**—A small umbrageous tree, usually 20 to 30 feet in height, bark smooth, grey. Abnormal leaves ovate-lanceolate, opposite, decussate, under 1 inch long, paler underneath. Found flowering in opposite leaf stage. Normal leaves linear-lanceolate to lanceolate, crowded, often opposite, under 3 inches long, acuminate, shortly petiolate; venation not prominent, intramarginal vein somewhat removed from the edge, lateral veins spreading, moderately oblique. Peduncles axillary, 1 to 2 lines long, with radiating heads of five to seven flowers. Buds sessile; calyx tube sub-cylindrical,  $1\frac{1}{2}$  lines long and twice or more than twice as long as the conical operculum.

**Fruit.**—Globular, truncate, sessile; rim thin; valves not exserted; 2 lines long and 2 lines in diameter.



*They very closely resemble those of E. stellulata, so that these two trees cannot be separated by their fruits.*

**Habitat.**—Kybean River, Monaro, New South Wales, at an altitude of 3,500 feet.

**REMARKS.**—This species is primarily separated from its congener *E. stellulata* by the leaf venation, partly by its bark, and chemical constituents.

**ESSENTIAL OIL.**—Material of this species for distillation was obtained from Kybean, N.S.W., in December, 1908.

The yield of oil was 0.7 per cent. The crude oil was of an amber colour, and had an odour resembling the cineol-pinene oils. It was rich in cineol, contained pinene, but phellandrene was absent. The small amount of ester was probably geranyl-acetate. The first distillate contained the volatile aldehydes valeraldehyde and butaldehyde. The oil is a good one of the cineol class, and it is unfortunate that the yield is not greater. The rectified oil was yellowish in tint, due to the influence of the particular phenol present; this colour is characteristic of the oils of the typical "Gums."

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9177$ ; rotation  $a_D + 3.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4644$ , and was soluble in 1.2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.6.

On rectification, 2 per cent. distilled below  $169^{\circ}\text{C.}$  (corr.). Between  $169-193^{\circ}$ , 93 per cent. distilled, and between  $230-240^{\circ}$ , 2 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9155$ ; rotation  $a_D + 3.5^{\circ}$ ; refractive index at  $20^{\circ} = 1.4617$ .

Second fraction     ,,     ,,     = 0.9285; rotation dextro-rotatory; refractive index at  $20^{\circ} = 1.4781$ .

The cineol, determined by the phosphoric acid method, was 69 per cent. in the crude oil (O.M.).

It is very probable that the higher boiling portion contained the liquid form of eudesmol, particularly as it was dextro-rotatory, and no crystalline body was detected.



## 78. *Eucalyptus pumila*.

(R.H.C., Proc. Roy. Soc., N.S.W., 1918, p. 453.)

**Systematic.**—A tall shrub, "Mallee" like, reaching 15 to 20 feet in height. Branchlets angular at extremities. Abnormal leaves ovate to ovate-lanceolate. Normal leaves lanceolate, falcate, to ovate-lanceolate, acuminate; venation fairly prominent, intramarginal vein close to the edge of the leaf, lateral veins inclined at about  $40^\circ$  to the mid-rib. Flowers about six in umbel, the common peduncle axillary or lateral, about 5 lines long. Buds almost sessile; calyx tube conoidal, 2 lines long, and half as long as the blunt pointed conical operculum.

**Fruit.**—Hemispherical to turbinate, rough, somewhat shining; rim thick, convex; valves thick, usually four, well exserted; 3 lines long and 3 to 4 lines in diameter.



*Amongst other species the nearest in shape to these are E. dealbata and E. tereticornis.*

**Habitat.**—Near Pokolbin, New South Wales.

PLATE XXXVIII.



EUCALYPTUS PUMILA. R.H.C.



W. Marshall, del.

EUCALYPTUS PUMILA, R.H.C.

no. 1000  
1000000000



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from near Pokolbin, N.S.W., in August, 1907. The yield of oil was 1·6 per cent.

The oil from this species is one of the best of the cineol-pinene class of Eucalyptus oils, and compares favourably with those from *E. polybractea*, *E. Smithii*, and others. As it grows in the "Mallee" form the leaves would not be difficult to collect, and if occurring in quantity should be profitable for oil distillation. The rectified oil was slightly tinged yellow, as are practically all the rectified oils of this class. Cineol was the chief constituent, three-quarters of the oil consisting of that substance. Pinene was present, but phellandrene was absent. Although the pinene was dextro-rotatory, yet that form only slightly predominated, consequently the rotations for the crude and rectified oils were almost the same. The lower boiling aldehydes, butaldehyde and valeraldehyde, were present, as is usual with oils of the cineol-pinene class. The higher boiling portion contained some sesquiterpene, and it is probable that aromadendral was also present in small amount.

The crude oil had specific gravity at 15° C. = 0·9237; rotation  $a_D + 2·3^\circ$ ; refractive index at 20° = 1·4683, and was soluble in 1·1 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3·2.

On rectification the usual amount of acid water and volatile aldehydes came over below 167° C. (corr.). Between 167–183°, 89 per cent. distilled, and between 183–250°, 8 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0·9166; rotation  $a_D + 2·2^\circ$ ; refractive index at 20° = 1·4668.

Second    ,,            ,,            ,,       = 0·9359; rotation  $a_D + 0·6^\circ$ ; refractive index at 20° = 1·4760.

The cineol was determined by the phosphoric acid method; the result was 74 per cent. of that constituent in the crude oil.

## 79. *Eucalyptus pulverulenta*.

(Sims, in Bot. Mag., t. 2087.)

(Syn. *E. pulviger*, A. Cunn.)

**Systematic.**—A tall shrub, with a "weak green stem hardly able to support itself" (Sims), the bark on the thicker stems is smooth, flaking off near the base, where only specimens of the wood can be obtained. The lower parts of the green stems have the appearance of rattans or palms by the scars left by the base of the old deciduous leaves, which produce an effect somewhat similar to the nodes of the bamboo. To our knowledge no other Eucalypt has this character. Leaves sessile, ovate, cordate, orbicular or broadly ovate, obtuse, or very shortly acuminate, not crenulate, or hardly perceptible, yellowish-green and slightly shining, or mealy white, rigid, coriaceous; venation distinct, lateral veins spreading, intramarginal vein removed from the edge. Peduncles axillary,

opposite, terete, under 3 lines long, bearing three comparatively large flowers, glaucous. Calyx campanulate, 3 lines long and 3 lines in diameter; operculum conical, shorter than the calyx.

**Fruit.**—Sessile, hemispherical or inclined to bell-shape; rim thick, truncate, slightly rounded or countersunk, with a narrow edge; valves slightly exserted; 3 to 4 lines in diameter.



*These fruits are distinctive from those of other species except E. cinerea.*

**Habitat.**—Cox's River, Cow Flat, New South Wales.

**REMARKS.**—At the time of the publishing of the first edition, the systematic recognition of this species by us was very much challenged, and so the remarks in that edition were given rather fully in order to support our contention that it is not *E. cordata* of Tasmania or *E. cinerea* of New South Wales.

As its specific rank is now firmly established, those remarks (*loc. cit.*) are omitted from this edition.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Bathurst, N.S.W., in February, 1901. The yield of oil was large, 33 ounces being obtained from 93 lb. of leaves and branchlets, equal to 2.22 per cent. The branchlets were stiff and woody, owing to the peculiar structure of this species; consequently more stems were present than was generally the case with most other Eucalypts, so that the result demonstrates how great is the quantity of oil secreted in the leaves of this species. The crude oil was of an amber colour, and had an odour resembling those of the cineol-pinene class of Eucalyptus oils. It was very rich in cineol; pinene was present, but phellandrene was absent. The chemical constituents and physical properties of the oil of this Eucalypt are in agreement with those of *E. cinerea*. The esters were rather pronounced.

The crude oil had specific gravity at 15° C. = 0.9236; rotation  $a_D + 2.12^\circ$ ; refractive index at 20° = 1.4629, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 18.4.

On rectification 2 per cent. distilled below 166° C. (corr.). Between 166–183°, 78 per cent. distilled, and between 183–196°, 15 per cent. distilled. It is thus evident that the sesquiterpene and other high-boiling constituents were only present in small amount. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9208; rotation  $a_D + 2.45^\circ$ .

Second " " " = 0.9217; " not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 60 per cent. in the crude oil (O.M.).

The above sample of oil had been stored in the dark, and in August, 1919, was again analysed. The increase in cineol was distinctly shown, the rectified oil at that time being quite equal to that of *E. polybractea*. 92 per cent. distilled below 190° C. The crude oil and the redistilled portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9305; rotation  $a_D + 2^\circ$ ; refractive index at 20° = 1.4609.

Rectified portion " " " = 0.9250; rotation  $a_D + 2.5^\circ$ ; refractive index at 20° = 1.4594.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 88 per cent. By the rapid phosphoric acid method it was 74 per cent. when calculated for the crude oil. Terpeneol was detected in the rectified portion.





*EUCALYPTUS PULVERULENTA*, SIMS.

Reproduced from the "Botanical Magazine," 1819. It will thus be seen that this rare Eucalyptus was grown in England from seed forwarded from Australia at that early period after the foundation of the Colony in 1788.







R.T.B., del.

**EUCALYPTUS MORRISII, R.T.B.**

GREY MALLEE.

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## 80. *Eucalyptus Morrisii*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 312, t. XVIII).

Grey Mallee.

**Systematic.**—A "Mallee" of rather dense growth, or somewhat spreading; usually about 15 feet high, or somewhat higher; stems 2 to 3 inches in diameter; rarely growing to tree size of about 25 or 30 feet high, and 6 to 12 inches in diameter. Stems mostly hollow. Branchlets often flattened or quadrangular. Bark grey, somewhat fibrous, or on very old trees even furrowed, approaching that of an "Ironbark." Abnormal leaves petiolate, generally lanceolate in form, sometimes narrower and sometimes broader than the mature ones, opposite, or with a tendency to become so. Normal leaves lanceolate-acuminate, on petioles of about 1 inch long, occasionally falcate, about 6 inches long and up to 1 inch wide, not shining; venation spreading, very prominent on both sides, intramarginal vein removed from the edge. Peduncles axillary, not numerous, flattened and twisted, short, under 6 lines, mostly 3 to 4 lines long, bearing three to seven short pedicellate or sessile buds, mostly in threes. Calyx tube hemispherical, 3 lines in diameter; operculum obtuse, conical, 3 lines long.

**Fruit.**—Hemispherical, shortly pedicellate; rim pyramidal, and sometimes twice the length of the calyx; valves well exerted; 3 to 4 lines in diameter.



*No other species of fruits appear to have the facies of this one, and so presents no difficulty in identification.*

**Habitat.**—Near Girilambone, on stony or rocky hills; thence on hills across country to Cobar; also near Coolabah, New South Wales.

**REMARKS.**—This species is a "Mallee" of the Northern interior of this State, where it is found associated with the "Green Mallee," *E. viridis*, R.T.B., and at times with *E. oleosa*, F.v.M. The bark is sometimes persistent right out to the branches, whilst on some trees it is smooth nearly half-way down. The persistent bark is rougher and more furrowed in the larger trees, making a slight approach to that of the "Ironbarks." It attains, not its greatest height, but certainly its greatest diameter, on the highest hills amongst the roughest and rockiest parts. Perhaps the most remarkable specific morphological character about it is the rim of the fruits. The word "domed" hardly expresses correctly this feature, for, merging into the valves at the top, it forms, as it were, a truncate cone, resting on the hemispherical calyx. This conformation of the rim is noticeable as soon as the stamens begin to fall off, and from this stage until after its full development it gives the appearance to the fruit of a pathological affection or a monstrosity. The shape of the fruits, however, is constant throughout the extensive range of the species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Girilambone, N.S.W., in January, 1900. The yield of oil was 1.7 per cent. The crude oil was but slightly coloured, and had an odour resembling those belonging to the cineol-pinene class generally. The rectified oil was slightly tinged yellow, a character common to those of this group. The oil may be considered a good one for pharmaceutical purposes, although perhaps a little low in specific gravity in the spring and summer months, and as it contained a very small amount of high-boiling constituents, the greater portion (95 per cent.) distilled below 188° C. Pinene was the principal terpene, and phellandrene was absent; in fact, the oil may be considered to consist very largely of pinene and cineol, and to be rich in the latter constituent. The esters were not pronounced.

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9097$ ; rotation  $a_D + 6.1^{\circ}$ ; refractive index at  $20^{\circ} = 1.4636$ , and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.1.

On rectification, 5 per cent. distilled below  $167^{\circ}\text{C.}$  (corr.). Between  $167$ – $188^{\circ}$ , 90 per cent. distilled. The large fraction had specific gravity at  $15^{\circ}\text{C.} = 0.9095$ ; and rotation  $a_D + 6.55^{\circ}$ . The cineol, determined by the phosphoric acid method in the redistilled portion, and calculated for the crude oil, was 59 per cent. (O.M.).

Later a further consignment of material for distillation was obtained from the same district, but from another locality; the oil was found to be practically identical in composition with the first sample, although the specific gravity was a little higher. The yield of oil was 1.6 per cent. The specific gravity of the crude oil =  $0.9164$ ; and the optical rotation  $a_D + 3.76^{\circ}$ . The cineol, determined by the phosphoric acid method in the crude oil, was 63 per cent. (O.M.). It is thus seen that during the greater portion of the year the oil from this species would more than meet the requirement for specific gravity as laid down in the British Pharmacopœia.

The above samples were mixed together and stored in the dark, and in September, 1919, the oil was again analysed. 92 per cent. distilled below  $190^{\circ}\text{C.}$  The crude oil and the fractionated portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}\text{C.} = 0.9280$ ; rotation  $a_D + 5.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.4616$ .

Redistilled portion „ =  $0.9196$ ; rotation  $+ 4.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4596$ .

The cineol was determined by the resorcinol method in the fractionated portion and calculated for the crude oil; the result was 80 per cent. By the rapid phosphoric acid method it was 64 per cent., when calculated for the original oil.

## 81. *Eucalyptus Moorei*.

(J.H.M. & R.H.C., Proc. Linn. Soc., N.S.W., 1905, p. 191.)

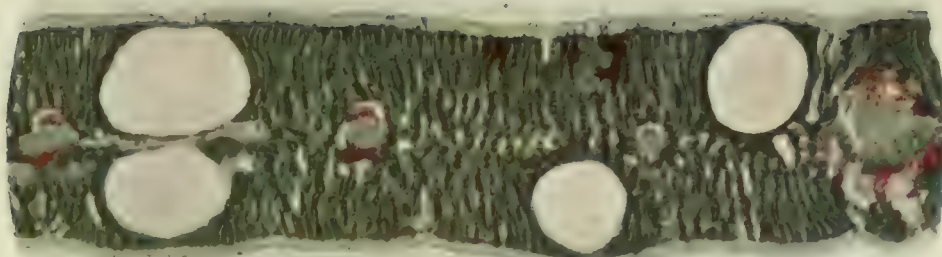
**Systematic.**—An erect, rather slender shrub up to 12 feet in height, forming dense clumps of small area; bark smooth, with the outer bark peeling off in ribbons. Abnormal leaves narrow, lanceolate, glaucous, oil glands profuse. Normal leaves narrow, very thick, smooth; venation scarcely showing, both sides shining, tips often hooked. Peduncles axillary, short, up to 2 lines long, bearing stellate clusters of buds. Flowers in dense heads numbering ten or more, sometimes flowering while in opposite leaf stage. Calyx narrow, turbinate, angular, about  $1\frac{1}{2}$  lines long; operculum angular, pointed, about the same length as the calyx tube, often reddish.

**Fruit.**—Globular, shining, smooth or somewhat rugose; rim narrow, countersunk; valves not exserted; about 2 lines long and 2 lines in diameter.



*These fruits are similar in shape to those of E. stellulata.*

**Habitat.**—On the highest portion of the Blue Mountain Tableland. Talwong in the Shoalhaven district is the southernmost locality, New South Wales.



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Transverse section of a portion of a leaf between the edge and mid-rib. This is a mountain species showing unusually large oil glands, the diameter extending the width of a strongly developed parenchymatous tissue below the upper and lower surfaces. The epidermis is differentiated into a well-defined inner layer of cells, and an outer faintly marked cuticle. The mesophyll occupies only a limited area in the centre of the section. x 75.

EUCALYPTUS MOOREI. J.H.M. & R.H.C.





**REMARKS.**—The size and shape of the leaves, and chemistry of the oil appear to be the chief specific distinctions from *E. stellulata*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were received from Blackheath, N.S.W., in September, 1919. The yield of oil was 0.8 per cent.

The crude oil was of a dark amber colour with an odour resembling the cineol-pinene oils generally. A small quantity of pinene was present, but phellandrene was absent. Cineol was present in quantity, and crystallised eudesmol was also pronounced. A solid paraffin was also detected. Esters were only present in small quantity.

The crude oil had specific gravity at 15° C. = 0.9289; rotation  $a_D + 6.12^\circ$ ; refractive index at 20° = 1.4699, and was soluble in 1.1 volume 70 per cent. alcohol. The saponification number for the esters and free acid was 6.1, and in the cold with two hours' contact it was 3.3.

On rectification 1 per cent. distilled below 172° C. (corr.). Between 172–193°, 73 per cent. distilled; between 193–276°, 10 per cent. came over, and between 276–281°, 13 per cent. distilled. These fractions gave the following results:—

|                                   |                                                                                            |
|-----------------------------------|--------------------------------------------------------------------------------------------|
| First fraction,                   | sp. gr. at 15° C. = 0.9183; rotation $a_D + 2.1^\circ$ ; refractive index at 20° = 1.4624. |
| Second       ,,       ,,       ,, | = 0.9331; rotation $a_D + 10.8^\circ$ ; refractive index at 20° = 1.4809.                  |
| Third       ,,       ,,       ,,  | = 0.9571; rotation not taken; refractive index at 20° = 1.5076.                            |

The cineol was determined by the resorcinol method in the first fraction; when calculated for the crude oil the result was 64 per cent. By the rapid phosphoric acid method it was 56 per cent. in the crude oil.

A portion of the oil was acetylated in the usual way, when the saponification number had risen to 52.4, and in the cold with two hours' contact it was 16.3. This result indicates that 13.4 per cent. of eudesmol, and 3.6 per cent. of free geraniol occurred in the crude oil.

The eudesmol was present in such quantity that it was prepared in a pure condition; the specific rotation was  $[a]_D + 35.5^\circ$ . The melting point was but 76° C. This low melting point was traceable to a small proportion of the paraffin still remaining, and when removed the melting point was 80° C.

The above amount of eudesmol is what was contained in the oil, but distillation was continued for some hours and a solid cake of eudesmol thus obtained floating on the condensed water; this amounted to about one-third of the total yield.

A sample of commercially distilled oil of this "Mallee," growing at Charley's Forest, between Nelligen and Mongarlowe, N.S.W., was submitted to us by Mr. Carlyle, in November, 1919. It had been distilled by the simple bush tank still, consequently much of the higher boiling constituents had not been obtained. The oil agreed very well with the sample distilled by us from the Blackheath material, and was equally rich in cineol. It had specific gravity at 15° C. = 0.924; rotation  $a_D - 3.7^\circ$ ; refractive index at 20° = 1.4634; cineol 70 per cent. by the phosphoric acid method.

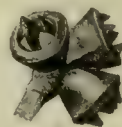
## 82. *Eucalyptus Muelleri*.

(T. B. Moore, in Roy. Soc., Tas., 207, 1886.)

### Brown Gum.

**Systematic.**—A large tree, attaining a height of 200 feet. Bark scaly at base, smooth above, reddish in colour, often blotched. Abnormal leaves, usually opposite, rounded or oval, crenulate, mucronate, sometimes cordate, sessile or shortly petiolate, averaging about 2 inches long and  $1\frac{1}{2}$  inch broad. Normal leaves ovate to lanceolate, thick, shining; venation not pronounced, intramarginal vein somewhat removed from the edge, lateral veins inclined at an angle of about  $30^\circ$  to the mid-rib. Flowers sessile, usually in threes, short, broad, angular, on axillary peduncles about 2 lines long. Buds reddish in colour; calyx tube almost hemispherical, flanged, about 2 lines long; operculum domed at first, surmounted by a blunt point.

**Fruit.**—Compressed, hemispherical, or semi-ovoid, sometimes ridged; rim convex; valves thick, exserted; about 3 lines long and 4 lines in diameter.



*The nearest in form is perhaps E. Baeuerleni or even E. unialata.*

**Habitat.**—Tasmania, high situations.

**REMARKS.**—Mueller, and now later systematists are inclined to regard this species as identical with *E. vernicosa*, and the oils do not assist much in their separation, but otherwise we fail to detect any other common character. The leaves, buds, and fruits of *E. vernicosa* have no resemblance whatever to those of *E. Muelleri*. The timber and bark are different, and further, the latter is a tree and *E. vernicosa* a "Mallee."

When planted in other countries they both grow true to the original and show no variation or gradation into each other.

**ESSENTIAL OIL.**—Material of this species for distillation was obtained from Mt. Wellington, Tasmania, at an altitude of about 3,000 feet; it was collected in July, 1908. The principal constituent in the oil was cineol, together with a fairly large amount of pinene. Phellandrene was not present, nor was it to be expected, judging from the botanical features of the species. There was rather a large amount of ester for oils of this class, and this appeared to be largely geranyl-acetate, as it was mostly saponified in the cold with two hours' contact. The crude oil was of a light-amber colour, and had an odour resembling those belonging to the pinene-cineol group. Volatile aldehydes were present, but could be separated without difficulty on redistillation.

The yield of oil from leaves and terminal branchlets was 1.28 per cent. The crude oil had specific gravity at  $15^\circ$  C. = 0.9096; rotation  $\alpha_D + 10.4^\circ$ ; refractive index at  $20^\circ$  = 1.4647, and was soluble in 4 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 15.3, while in the cold with two hours' contact it was 11.7.

On rectification, the usual amount of acid water and volatile aldehydes came over below  $166^\circ$  C. (corr.), at which temperature the oil commenced to distil. Between  $166$ – $173^\circ$ , 44 per cent. distilled; between  $173$ – $195^\circ$ , 45 per cent.;



the temperature then quickly rose to  $225^{\circ}$ , and between that temperature and  $252^{\circ}$ , 5 per cent distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9022$ ; rotation  $a_D + 14.1^{\circ}$ ; refractive index at  $20^{\circ} = 1.4603$ .

Second                   ,,                   ,,                   ,, =  $0.9149$ ; rotation  $a_D + 6.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4611$ .

Third                   ,,                   ,,                   ,, =  $0.9309$ ; rotation not taken; refractive index at  $20^{\circ} = 1.4859$ .

The cineol was determined in the portion distilling below  $195^{\circ}$  by the resorcinol method; the result was 60 per cent. when calculated for the crude oil. By the rapid phosphoric acid method it was 57 per cent. when calculated for the crude oil.

The results obtained with this oil, and also with those of *E. urnigera* and *E. vernicosa* show them to belong to the better class of cineol-pinene oils, but they suffer from the defect of containing rather too much pinene, consequently their specific gravities are reduced below 0.91. However, more than half the rectified oils of these species consists of cineol, and the supposed defect of specific gravity could easily be remedied if desired.

It is interesting to notice how closely the oil of this species agrees with that of *E. vernicosa*, as may be seen from the following table. The difference in yield is due to the coarser stems and less expansive leaves of *E. vernicosa*:—

|                                                               | <i>E. Muellerei.</i><br>Cineol-pinene oil, no<br>phellandrene. | <i>E. vernicosa.</i><br>Cineol-pinene oil, no<br>phellandrene. |
|---------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| Yield per cent.     ...     ...     ...     ...               | 1.28                                                           | 0.807                                                          |
| Specific gravity at $15^{\circ}\text{C.}$ ...     ...     ... | 0.9097                                                         | 0.9038                                                         |
| Rotation $a_D$ ...     ...     ...     ...                    | $+ 10.4^{\circ}$                                               | $+ 11.3^{\circ}$                                               |
| Refractive index at $20^{\circ}\text{C.}$ ...     ...     ... | 1.4647                                                         | 1.4642                                                         |
| Saponification number, esters, &c. ...                        | 15.3                                                           | 5.9                                                            |
| First fraction     ...     ...     ...     ...                | Below $173^{\circ}\text{C. } a_D + 14.1^{\circ}$ .             | Below $173^{\circ}\text{C. } a_D + 16.7^{\circ}$               |
| Second fraction     ...     ...     ...     ...               | Below $195^{\circ}\text{C. } a_D + 6.6^{\circ}$ .              | Below $194^{\circ}\text{C. } a_D + 9.4^{\circ}$ .              |
| Cineol     ...     ...     ...     ...                        | 57 per cent.                                                   | 52 per cent.                                                   |

The results of this investigation were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

### 83. *Eucalyptus longicornis*.

(F.v.M., in *Fragm.* XI, 14, 1878.)

Morrel.

**Systematic.**—A tree attaining a height of 120 feet, with a rugose, ash-coloured bark on the trunk, persisting to the branches. Leaves lanceolate, acuminate, about 4 inches long, thick and smooth, venation not conspicuous. Peduncles axillary or lateral, each bearing three to nine pedicellate flowers. Calyx tube semi-ovoid or turbinate, less than half as long as the conical, obtuse or acute operculum.

**Fruit.**—Ovoid or turbinate, truncate, sometimes contracted at the orifice; rim flat or concave; points of the valves formed by the split base of the style, acuminate, often connivent, much exerted.

*These fruits so much resemble those of E. oleosa, except for the coalescing of the valves at the top, that it was not thought necessary to depict them.*

**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—This sample of oil was distilled by Mr. P. R. H. St. John, in Melbourne, September, 1919, the material being collected from trees cultivated in the Botanic Gardens of that city. The yield of oil was 1.2 per cent. The crude oil was but little coloured, had an odour similar to those of the cineol-pinene oils generally, with a secondary aromatic one. Volatile aldehydes were not pronounced. The constituents present were dextro-rotatory pinene, cineol, esters, alcoholic bodies, and some sesquiterpene. Phellandrene was not detected.

The crude oil had specific gravity at 15° C. = 0.9203; rotation  $a_D + 5.0^\circ$ ; refractive index at 20° = 1.4670, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 10.8 by heating. There were no esters saponified in the cold. After acetylation, the saponification number was 51.9, of which amount 45.7 was saponified in the cold with two hours' contact. This result represents 11 per cent. of free alcohols calculated for the  $C_{10}H_{18}O$  molecule.

On rectification, 2 per cent. distilled below 160° C. (corr.). Between 160–172°, 20 per cent. distilled; between 172–193°, 62 per cent. came over; between 193–222°, 8 per cent. distilled, and between 222–265°, 7 per cent. These fractions gave the following results:—

|                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. = 0.8992; rotation $a_D + 13.8^\circ$ ; refractive index at 20° = 1.4615.                                 |
| Second                   ,,                   ,,                   = 0.9157; rotation $a_D + 5.5^\circ$ ; refractive index at 20° = 1.4645. |
| Third                   ,,                   ,,                   = 0.9430; rotation $a_D - 5.2^\circ$ ; refractive index at 20° = 1.4744.  |
| Fourth                   ,,                   ,,                   = 0.9527; rotation $a_D - 6.0^\circ$ ; refractive index at 20° = 1.4956. |



The cineol was determined by the resorcinol method in the portion boiling between 160–193°, and calculated for the original oil; the result was 61 per cent. By the phosphoric acid method, taken in the crude oil, the result was 56 per cent., thus indicating but a small proportion of absorbable constituents, other than cineol, in the portion distilling below 193° C. The alcohol was evidently a high-boiling one, and lævo-rotatory; it had a distinct cinnamon-like odour.

The oil at our disposal was not sufficient to enable further work to be done with this alcohol.

## 84. *Eucalyptus Perriniana*.

(F.v.M.)

**Systematic.**—A “Mallee” or small tree attaining a diameter of 1 foot, and sometimes up to 30 feet in height, with a smooth bark. The broad expanded base, from which spring a number of small stems, is very characteristic of this species. Branchlets, terete and glaucous. Leaves also glaucous, variable, both in size and shape, perfoliate, sessile cordate, decussate, opposite or alternate; venation faintly marked, lateral veins oblique, spreading, intramarginal vein well removed from the edge. Flowers in short axillary peduncles mostly, generally in threes, sessile or on a short pedicel. Calyx 2 to 3 lines long, 2 lines in diameter, bell-shaped; operculum shortly conical, edge overlapping the calyx.

**Fruit.**—Hemispherical to elongated or cylindrical; rim thickened, capsule sunk, valves not exerted; up to 5 lines long and under 3 lines in diameter.



*E. vernicosa* fruits more resemble this than any other.

**Habitat.**—Tingiringi Mountain and Snowy Mountains, New South Wales, at an elevation of 5,000 feet; north eastern Ranges of Victoria; Tasmania.

**REMARKS.**—The exudation which gives the common name “Cider Gum” to the Tasmanian Eucalyptus, *E. Gunnii*, is quite wanting in *E. Perriniana*. In New South Wales it occurs at an elevation of 5,000 feet, and appears there abruptly without transition forms to connect it with any species occurring on lower elevations. It forms on the highest points a dense Mallee scrub, *i.e.*, small trees up to 4 inches in diameter, springing from a large common root-stock, to the number of six or even more trees. This large root stock is present also when the trees grow singly and to proper tree size, up to 1 foot in diameter. The material of *E. Perriniana* from Tasmania, again illustrates the constancy of species, for the trees in that Island and on the mainland are identical and show no gradation to *E. Gunnii* in any way.

*Re. the Authorship of the species.*—In our first edition, we gave a description, and the authorship of this species to F.v.M., but later found that Mueller had not published the name or a description, and in our paper on Tasmanian Eucalypts we give a full description, and so put our names after it, not being aware that it had been previously described. Ewart, however (*Proc. Roy. Soc., Victoria*, vol. 26, p. 3), states that the authorship really belongs to Mr. L. Rodway, who was the first to publish the name and a “not complete description” (*Maiden, Crit. Rev.*, vol. III., p. 103). As we now understand that Mr. Rodway is agreeable to let Mueller’s name stand with the species, we forego any claim as the authors.

**ESSENTIAL OIL.**—Material for distillation was collected at Strickland, Tasmania, in July, 1912. The yield of oil was 1 per cent. The crude oil was reddish in colour, but this colour was readily removed, when it had a light amber tint. It contained a considerable amount of cineol. Pinene was present in rather a large quantity for a rich cineol oil, and phellandrene was



absent. Volatile aldehydes were pronounced, and these had a very objectionable odour, a character usual with this group of Eucalyptus oils. The odour of the rectified oil was similar to those of the cineol-pinene oils generally. It is a very fair commercial oil for pharmaceutical purposes, although the pinene is a little too pronounced.

The crude oil had specific gravity at 15° C. = 0.9119; rotation  $\alpha_D + 8.90^\circ$ ; refractive index at 20° = 1.4628, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 12.3.

On rectification a few drops of acid water and volatile aldehydes came over below  $167^{\circ}$  C. (corr.). Between  $167-173^{\circ}$ , 18 per cent. distilled; between  $173-194^{\circ}$ , 72 per cent. distilled; the temperature then quickly rose to  $250^{\circ}$  with only a few drops, while between  $250-268^{\circ}$ , 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8988; rotation  $a_D + 13.5^\circ$ ; refractive index at 20° = 1.4596.

Second        „        „        „        = 0.9118; rotation  $a_D = 159^\circ$ ; refractive  
index at  $20^\circ = 1.4608$ .

Third        „        „        „        = 0.9256; rotation  $a_D + 5.2^\circ$ ; refractive  
index at  $20^\circ = 1.4845$ .

The cineol was determined by the resorcinol method in the portion distilling below 194° C. and calculated for the crude oil; the result was 68 per cent. By the rapid phosphoric acid method it was 58 per cent. when calculated for the crude oil. The rectified oil of this species is tinged yellow, as is usual with most of the oils of this group. The indication from this is that the predominant phenol is the crystallised one.

The above analysis was published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

In September, 1913, material of this species was received for distillation from Tingiringi Mountain, Southern New South Wales. The yield of oil was 1.1 per cent. The oil was of an amber colour and had a rank odour, cough-producing aldehydes being present in some quantity. In its general characters the oil was similar to that from the species from Tasmania, with the exception that the ester was present in greater amount, and the cineol a little less.

The crude oil had specific gravity at 15° C. = 0.9082; rotation  $a_D + 5.7^\circ$ ; refractive index at 20° = 1.4612, and was soluble in 7 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 52.5.

On rectification 2 per cent. distilled below  $167^{\circ}\text{C}$ . (corr.). Between  $167$ – $173^{\circ}$ , 11 per cent. distilled; between  $173$ – $193^{\circ}$ , 63 per cent. distilled, and between  $244$ – $268^{\circ}$ , 16 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8925; rotation  $a_D + 14.1^\circ$ ; refractive index at 20° = 1.4536.

Second " " " = 0.9001; rotation  $\alpha_D + 7.8^\circ$ ; refractive index at  $20^\circ = 1.4521$ .

Third " " " = 0.9318; rotation  $\alpha_D + 2.6^\circ$ ; refractive index at  $20^\circ = 1.4890$ .

The saponification number for the esters in the first fraction was 51.4, and in the second 53.4, so that the ester is a low-boiling one.

Another 100 c.c. of the oil was distilled to 190° C.; the saponification number for the ester in this was 57.2, so that practically the whole ester in the oil was the low-boiling one, determined as the butyl-ester of butyric acid. (See the article dealing with this substance.)

The cineol, determined by the resorcinol method in the portion boiling below 190° C., and calculated for the crude oil, was 50·3 per cent.

When it was found that the ester in the oil of this species was a low-boiling one it was decided to revert to the original oil from the Tasmanian trees; fortunately the fractions had been preserved. The saponification number for the esters in the first fraction was 45·8, so that here again the greater portion of the esters was the low-boiling one, and from the odour and other tests was evidently butyl-butyrate, as in the oil from the New South Wales material.

## 85. *Eucalyptus costata*.

(R. Br.)

(Desc. by Schau., in Walp. Repert., ii, 925, 1843, under *E. angulosa*, and by Mueller under Brown's name, Trans. Vic. Inst., 1854, 33, and recently by Luehmann, Vic. Nat., vol. xiii, p. 147, 1897, under the name of *E. torquata*.)

**Systematic.**—A small tree, reaching a height of 20 to 30 feet, with a rough bark. Leaves lanceolate to broad lanceolate, acuminate, often uncinat, thick, coriaceous and shining, usually under 5 inches long; venation very indistinct, except in the young foliage, when the vascular bundles are marked by grooves on the leaf surface, intramarginal vein removed from the edge, lateral veins more or less spreading, inclined at about 30° to the mid-rib. Peduncles axillary or lateral, flattened, about 9 lines long, each bearing an umbel of three to seven flowers. Buds shining, with seven to ten ridges, shortly pedicellate; calyx tube urn- or bell-shaped, 4 to 5 lines long; operculum 4 lines long, at first domed and slightly greater in diameter than the calyx, in some cases the upper half abruptly contracted into a narrow cone.

**Fruit.**—Truncate-ovoid, inclined to be urn-shaped, more or less longitudinally ribbed, shining; rim convex, the periphery concave due to the prominent groove; valves not exserted; from 5 to 10 lines long and 4 to 7 lines in diameter at the widest part.

*A very characteristic fruit and one which has little resemblance to E. incrassata of Western Australia, although it has sometimes been confounded with it, the pronounced ribs readily distinguishing the two species.*

**Habitat.**—Victoria, South Australia and Western Australia (Coolgardie, Luehmann), and South West of New South Wales.



**REMARKS.**—The specimens which have come under our notice, and the published localities of others, show that this species has a wide range, and it would appear now that it has been recorded under several specific names. We have given the authorship to Robert Brown, who collected and gave it the name *E. costata*, although Scharer described it later, 1843, under *E. angulosa*. Mueller described it, 1854, Trans. Vict. Inst., p. 33, under Brown's name. The smaller fruited variety was described by Luehmann under the name of *E. torquata*, Vic. Nat., vol. xiii, p. 147, 1897. To add to the confusion the whole of these have been regarded as *E. incrassata* and its varieties, whilst the material collected by Labillardiere and F. v. Mueller in Western Australia prove that *E. costata* is not that species.



**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were forwarded by Mr. Walter Gill, the Conservator of Forests, South Australia. The material was collected at the Parilla Forest Reserve, of that State, in October, 1919. The yield of oil was 0.9 per cent.

The crude oil was red in colour and had an odour resembling the cineol-pinene oils generally. The constituents present were dextro-rotatory pinene, cineol, alcoholic bodies, a small amount of esters and a little sesquiterpene. Phellandrene was absent, and eudesmol not detected.

The crude oil had specific gravity at 15° C. = 0.9216; rotation  $a_D + 4.8^\circ$ ; refractive index at 20° C. = 1.4657, and was soluble in 1.2 volume 70 per cent. alcohol. The saponification number for the esters and free acid was 4.5. After acetylation it was 36.9, and in the cold with two hours' contact it was 27.

On rectification, 2 per cent. distilled below 165° C. (corr.). Between 165–171°, 18 per cent. distilled; between 171–193°, 67 per cent. came over; between 193–235°, 5 per cent. distilled, and between 235–267°, 7 per cent. These fractions gave the following results:—

|                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. = 0.9064; rotation $a_D + 11.8^\circ$ ; refractive index at 20° = 1.4603.       |
| Second        „        „        „        = 0.9173; rotation $a_D + 5.7^\circ$ ; refractive index at 20° = 1.4612. |
| Third        „        „        „        = 0.9340; rotation $a_D - 5.0^\circ$ ; refractive index at 20° = 1.4703.  |
| Fourth       „        „        „        = 0.9418; rotation too dark; refractive index at 20° = 1.4944.            |

These results closely approximate to those of *E. calycogona*, with the exception that the latter contained a little more pinene and consequently less cineol.

The cineol was determined by the resorcinol method in the portion distilling between 165–193° C., and calculated for the crude oil; the result was 67 per cent. By the phosphoric acid method it was 57 per cent. when calculated for the crude oil.

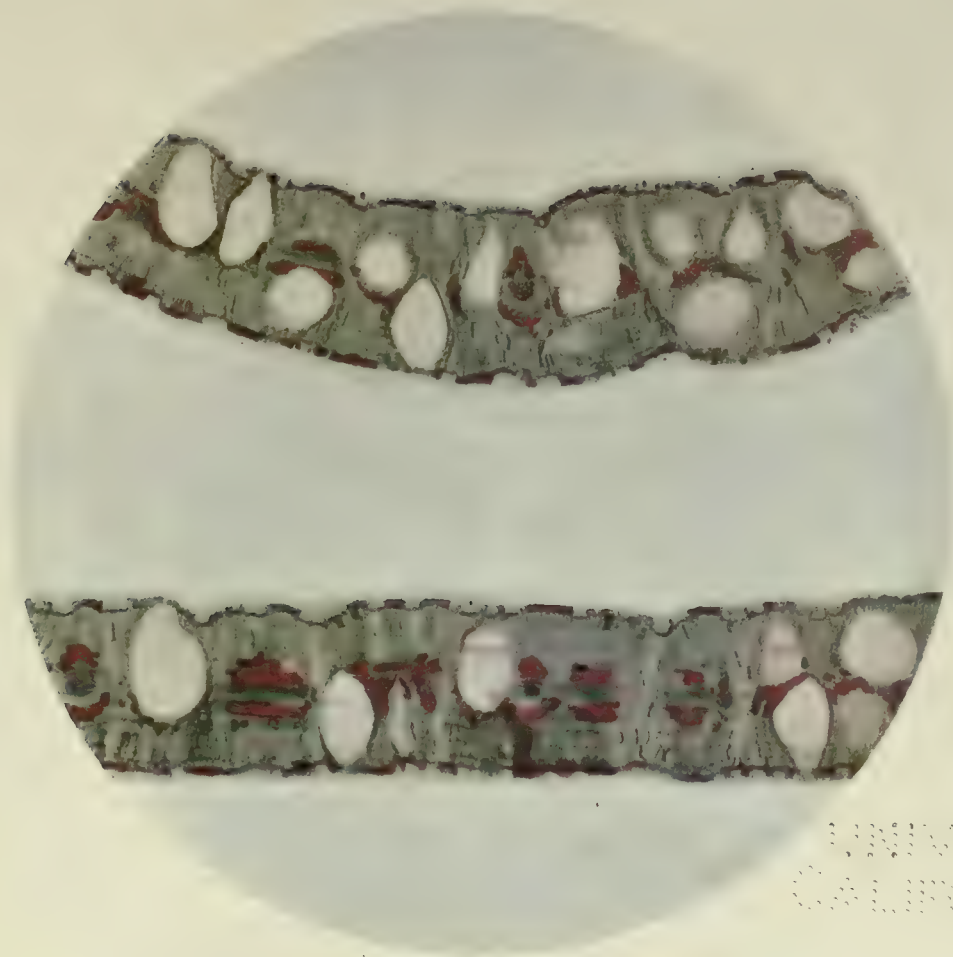
Material of the large fruited variety was also received for distillation from Mr. Walter Gill, the Conservator of Forests of South Australia. It had been collected on the West Coast of that State, in the Port Lincoln District, in April, 1920.

The yield of oil was 1.2 per cent. The crude oil was red in colour and had an odour similar to those belonging to the cineol-pinene groups of Eucalyptus oils. The constituents present were dextro-rotatory pinene, cineol, alcoholic bodies, a small amount of esters, and some sesquiterpene. Phellandrene and aromadendral were not present, nor was crystallised eudesmol detected. The results with the oil of this form show it to agree with that of the small fruited variety, with the exception that the pinene was more abundant and the cineol correspondingly less in amount, which may be accounted for by the difference in the time of the year.

The crude oil had specific gravity at 15° C. = 0.9023; rotation  $a_D + 11.8^\circ$ ; refractive index at 20° = 1.4676, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 5.8 by heating, and 5.2 in the cold, with two hours' contact.

After acetylation the saponification number was 36.25 by heating, and 22.34 in the cold. These results agree with the above.





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The dry country habitat of this species is indicated by the large number of oil glands seen in the two cross sections of the leaves. In this case nature has evidently responded to the physical conditions obtaining in the home of this Eucalyptus, and being so provided can by the volatilisation of the essential oil surround itself during excessive heat by a perfume medium, and, by warding off the solar heat rays, reduce transpiration and so live on when other plants less favoured by nature to resist heat, perish. The short red bands in the middle of the sections show the large number of vascular bundles present (cut more or less obliquely). The sunken stomata are also a feature of this species.  $\times 40$ .

*EUCALYPTUS COSTATA*, R.Br.

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On rectification, 1 per cent. distilled below 162° C. (corr.). Between 162–173°, 5 per cent. distilled; between 173–193°, 36 per cent. came over, and between 193–276°, 10 per cent. distilled. These fractions gave the following results:—

|                 |                              |                               |                                   |
|-----------------|------------------------------|-------------------------------|-----------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8901 ; | rotation $a_D + 18.6^\circ$ ; | refractive index at 20° = 1.4638. |
| Second          | „ „ „ = 0.9052 ;             | rotation $a_D + 8.0^\circ$ ;  | refractive index at 20° = 1.4647. |
| Third           | „ „ „ = 0.9332 ;             | rotation $a_D + 0.5^\circ$ ;  | refractive index at 20° = 1.4876. |

The cineol was determined by the rapid phosphoric acid method in the crude oil; the result was 35 per cent.

## 86. *Eucalyptus maculosa*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1899, p. 598, t. XLIV.)

**Spotted Gum or Brittle Gum.**

**Systematic.**—A tree rarely exceeding 60 feet in height, usually from 20 to 40 feet. Bark smooth to the ground. Abnormal leaves thin, lanceolate, or oval lanceolate, 2 or 3 inches long, mostly alternate; intramarginal vein removed from the edge. Normal leaves lanceolate, or narrow lanceolate, falcate, not shining, same colour on both sides; venation faintly marked, or rather obscure, intramarginal vein close to or slightly removed from the edge, lateral veins oblique. Some trees have the leaves quite rigid and erect. Peduncles axillary, slender, under 6 lines long, bearing from four to sixteen, occasionally twenty sessile or shortly pedicellate flowers. Calyx turbinate, about 1 line long; operculum of equal length to the calyx, obtuse.

**Fruit.**—Hemispherical mostly, occasionally slightly turbinate, shortly pedicellate; rim shortly domed; valves slightly exserted; about 2 lines in diameter.



*In form they range from a small to a medium sized E. viminalis fruit, and in the latter case somewhat resemble those of E. Smithii.*

**Habitat.**—Coast District of New South Wales and Victoria.

**REMARKS.**—It grows in poor, open, forest country up to 50 or 60 feet in height, and from 1 to 3 feet in diameter, with a rather dense head. The bark is of different shades of grey, or bluish or yellow, with spots of about the same size and shape as those of *E. maculata*, Hook., the true "Spotted Gum." It has affinity with *E. Smithii*, R.T.B., in the fruits (in some instances) and particularly in the chemical composition of its oil. With the original "Spotted Gum," *E. maculata*, Hook, it has little or no affinity. On account of the markings on the bark it can with equal justice be called "Spotted Gum," as well as *E. maculata*, but to distinguish it from that species and to record its field character, the name of *E. maculosa* was given to it. The two species have so far not been found together in the same locality. It has in the past probably been confused in herbaria with *E. hamastoma*, Sm. var. *micrantha*, D.C. or *E. Rossii*. Its chemical constituents connect it with *E. Smithii*, R.T.B., as also do the shape of the fruits, and occasionally the rough bark at the base of the trunk,



**ESSENTIAL OIL.**—Leaves and branchlets for oil distillation were obtained from Bungendore, N.S.W., in July, 1898. The yield of oil was 1.1 per cent. The crude oil was of a light amber colour, and had an odour resembling those of the cineol-pinene class. The presence of pinene in the oil was determined, but it is evident that the dextro-rotatory form does not predominate to any great extent; phellandrene was absent. The sesquiterpene was present in small amount. One peculiarity of the oil of this species is, that the right rotation of the crude oil is greater than that of the first fraction, thus indicating the presence of a constituent in the higher boiling portion which has right rotation. This peculiarity of rotation is of rare occurrence in Eucalyptus oils, because, generally, it is the pinenes or the phellandrene that determine the optical rotation of the oil, and, of course, these low-boiling terpenes come over first on distillation, so that, in most cases, the rotation of the first fraction of dextro-rotatory Eucalyptus oils is higher than that of the crude oil. This constituent is present in several of the oils at this end of the group (*E. Rossii* and others), and is eudesmol in the liquid form. (See the article dealing with this substance.)

The crude oil had specific gravity at 15° C. = 0.9158; rotation  $a_D + 3.35^\circ$ ; refractive index at 20° = 1.4684, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 21.3.

On rectification 2 per cent. distilled below 170° C. (corr.). Between 170–188°, 87 per cent. distilled; between 188–235°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9075; rotation  $a_D + 3.0^\circ$ .

Second „ „ „ = 0.9176; „ not taken.

The cineol, determined in the crude oil by the phosphoric acid method, was 46 per cent. (O.M.).

Material of this species was also obtained at Towrang, N.S.W., in October, 1900. The oil was similar in character to that from Bungendore, although at this time of the year it had a higher specific gravity, a less amount of ester, and contained a greater proportion of cineol. It showed the same peculiarity in optical rotation and had the same solubility in alcohol.

The specific gravity at 15° = 0.9229; rotation  $a_D + 2.3^\circ$ ; saponification number 8.7, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol.

The cineol, determined in the crude oil by the phosphoric acid method, was 58 per cent. (O.M.).

The above samples were mixed together, stored in the dark, and in November, 1919, the oil was again analysed. Very little alteration had taken place during the nineteen years it had been kept, except that the specific gravity had increased somewhat, and apparently the cineol a little also, although this alteration was not so pronounced as with the crude oils of some species. 82 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following result:—

Crude oil, sp. gr. at 15° C. = 0.9433; rotation  $a_D + 3.7^\circ$ ; refractive index at 20° = 1.4688.

Large fraction „ „ = 0.9182; rotation  $a_D + 2.4^\circ$ ; refractive index at 20° = 1.4624.

The cineol was determined by the resorcinol method in the rectified portion, and calculated for the crude oil; the result was 65 per cent. By the rapid phosphoric acid method it was 55 per cent. when calculated for the crude oil.



W. Marshall, del.

EUCALYPTUS MACULOSA. R.T.B.  
A SPOTTED GUM.





## 87. *Eucalyptus goniocalyx*.

(F.v.M., in *Fragm.*, vol. ii, 48, 1860.)

A Mountain Gum.

**Systematic.**—A very tall tree with a smooth bark, except for a few feet at the base, found mostly on basalt and granite ridges. Abnormal leaves cordate, sessile, acuminate, 6 inches long and 2 inches broad, dark-coloured above, lightish underneath; branchlets square. Normal leaves lanceolate, falcate, sometimes as much as 2 feet long and 3 inches broad; venation fairly distinct, intramarginal vein removed from the edge. Peduncles axillary, few, under 1 inch long, flattened. Buds angular, sessile or shortly pedicellate, 7 to 8 lines long; operculum shortly acuminate, obtuse.

**Fruit.**—Ovate-truncate, oblong or hemispherical, pedicellate, only occasionally sessile; rim countersunk; valves inserted or, when hemispherical, the valves are slightly exerted; about 6 lines long and 4 lines in diameter.



*The pyriform fruits closely resemble those of E. obliqua and E. Delegatensis and somewhat E. regnans. The hemispherical form is very much like those of Tristania conferta, a non-Eucalypt.*

**Habitat.**—Coast range from the Blue Mountains, New South Wales, well into Victoria and South Australia.

**REMARKS.**—The specific name in this case is not a good one, in that it applies much better to quite half-a-dozen other Eucalypts, and it is owing to this fact, that several good species have, in the past, been confounded with it. It is another instance where morphology fails in the classification of Eucalypts. "Mountain Gum" is one of the finest of our forest trees, but, unfortunately, is sometimes found in inaccessible gullies. The timber is hard, close-grained, interlocked, pale-coloured, and very durable. The timber alone differentiates this species from all others that have from time to time been confounded with it. Mueller's plate of this species in his *Eucalyptographia* appears to include species other than *E. goniocalyx*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, N.S.W., in August, 1898. The yield of oil was 0.96 per cent. The crude oil was lemon-yellow in colour, and had an odour resembling those of the richer cineol-pinene Eucalyptus oils. The presence of volatile aldehydes was pronounced. The oil of this species was rich in cineol, contained dextro-rotatory pinene, but phellandrene was absent. Eudesmol was present in the crystallised form, and the fourth fraction consisted largely of that constituent, together with the sesquiterpene. On standing some time the crude oil became turbid, eventually depositing a whitish powdery substance. Many of the oils of this class of Eucalyptus form this deposit on keeping, although quite clear when freshly distilled. (See the article dealing with this substance in this work.)

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.9125$ ; rotation  $a_D + 7.2^{\circ}$ ; refractive index at  $20^{\circ} = 1.4689$ , and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 13.3.

On rectification 2 per cent. distilled below  $169^{\circ}\text{C.}$  (corr.). Between  $169-171^{\circ}$ , 25 per cent. distilled; between  $171-183^{\circ}$ , 60 per cent. distilled; between  $183-260^{\circ}$ , 5 per cent. came over, and between  $260-275^{\circ}$ , 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.9045$ ; rotation  $a_D + 9.58^{\circ}$ .

Second " " " " =  $0.9110$ ; " " +  $5.6^{\circ}$ .

Third " " " " =  $0.9220$ ; " " not taken.

Fourth " " " " =  $0.9459$ ; " " "

The cineol, determined by the phosphoric acid method in the crude oil, was 56 per cent. (O.M.). The pinene, when separated, readily formed the nitrosochloride, which melted at the correct temperature.

Material of this species was also obtained from Katoomba, N.S.W., in May, 1900. The oil was practically identical with the above. The yield of oil was 1 per cent. The specific gravity of the crude oil =  $0.9117$ ; optical rotation  $a_D + 4.35^{\circ}$ . The cineol, determined by the phosphoric acid method in the crude oil, was 55 per cent. (O.M.). Crystallised eudesmol was present, also pinene, but not phellandrene. The esters were valeric acid ester and an acetic acid ester, as the presence of both these acids was chemically determined. The crude oil formed a clear solution with  $1\frac{1}{2}$  volumes 70 per cent. alcohol.

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. Not much alteration had taken place during the twenty-one years the oil had been kept; and no increase in cineol was observed. 90 per cent. distilled below  $190^{\circ}\text{C.}$  The crude oil and the fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}\text{C.} = 0.9127$ ; rotation  $a_D + 4.3^{\circ}$ ; refractive index at  $20^{\circ} = 1.4694$ .

Fraction " " " " =  $0.9078$ ; rotation  $a_D + 4.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.4663$ .

The cineol was determined by the resorcinol method in the fractionated portion and calculated for the crude oil; the result was 65 per cent. By the phosphoric acid method it was 56 per cent. when calculated for the crude oil.

In Wittstein's work (trans. F.v.M.), page 148, the oil of *E. goniocalyx* is stated to be pale yellow, of pungent, penetrating, rather disagreeable odour; taste, exceedingly unpleasant; specific gravity,  $0.918$ ; boils at  $152-175^{\circ}$ . These results agree closely with our own, thus indicating that the material had been distilled from the species stated. The presence of a fair amount of dextro-rotatory pinene is also indicated by Wittstein's figures of boiling-point, whilst the unpleasant odour mentioned is due to the predominance of the volatile aldehydes, and also perhaps to the esters. The yield of oil from this species, prepared for the Exhibition of 1862, was 1 per cent., which also agrees with our results. The relative constancy of constituents in the oil of the same species of *Eucalyptus* is thus again illustrated.





*R.T.B., del. ad nat.*

**EUCALYPTUS GONIOCALYX, F.V.M.**  
MOUNTAIN GUM.





## 88. *Eucalyptus globulus*.

(Labill., Voy. I, 153, t. XIII.)

Blue Gum.

**Systematic.**—A lofty tree with a smooth, whitish-blue bark. Abnormal leaves sessile, or shortly petiolate, cordate, covered (as also the twigs) with a glaucous bloom. Normal leaves lanceolate, falcate, 9 inches to 1 foot long, rather thick; venation prominent, lateral veins spreading, oblique, intramarginal vein removed from the edge. Flowers large, generally occurring in threes, in the axils of the leaves, sessile or on very short thick pedicels. Calyx tube broadly turbinate, thick woody, more or less ribbed and rugose or warty or nearly smooth,  $\frac{1}{2}$  to  $\frac{3}{4}$  inch diameter; operculum flattened, surmounted by a thick centre, warty. A smooth secondary operculum is often found in this species.

**Fruit.**—Hemispherical or cup shaped, tuberculate, and strongly ribbed; rim rounded or quite flat and broad, and a pronounced groove below the edge; valves short, depressed or exserted . . . . .  
Up to  $\frac{3}{4}$  inch long and 1 inch in diameter or more.



*A fruit easily distinguished from any other of the genus. A small, smooth fruited form that has a wide distribution, and seed distributed abroad, is not E. globulus but E. St. Johni, R.T.B.*

**Habitat.**—Occurs in isolated patches on the southern half of the coast range of New South Wales; Tasmania; Victoria.

**REMARKS.**—No species of *Eucalypt* has received so much attention, both from botanists and chemists, as this particular tree. Mueller devotes several pages to it in his *Eucalyptographia*, and as his figure of the species is excellent, it is reproduced here. The large white or cream-coloured flowers, the warted sessile fruits, the two opercula, the square branchlets, and the glaucous sessile abnormal leaves are all characteristic features. It is one of the Tasmanian species which also occur on the mainland of Australia, and has a fairly wide distribution in the south-eastern parts, extending as far north in this State as Mount Corricudgy. The tree is a very rapid grower, and for this reason is extensively planted in California and South Africa, where timber is in very great request for the mines and fuel. The wood is pale-coloured, fairly hard, easily worked, but difficult to season. Its occurrence in this State is patchy and so not much used for oil distillation. It has been extensively planted in Algeria and in Europe, and the oil from the former locality enters into competition with the Australian product.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Jenolan, N.S.W., in August, 1900. The yield of oil was 0.92 per cent. The crude oil was but little coloured, and had the characteristic odour of all those belonging to the richer cineol-pinene class of the "Gum" group of *Eucalypts*. The oil was rich in cineol, contained some pinene, but phellandrene was absent. Eudesmol was detected in very small amount in the higher boiling portions, and the sesquiterpene was also present in the oil boiling above 260° C.

The crude oil had specific gravity at 15° C. = 0.913; rotation  $\alpha_D + 8.4^\circ$ ; refractive index at 20° = 1.4663, and was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.1.

On rectification, 2 per cent. distilled below  $165^{\circ}$  C. (corr.). This portion consisted largely of volatile aldehydes with some acid water. Between  $165$ – $183^{\circ}$ , 87 per cent. distilled; between  $183$ – $260^{\circ}$ , 4 per cent. came over. and between  $260$ – $270^{\circ}$ , 2 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.9094; rotation  $a_D + 8.7^{\circ}$ .

Second    "               "               "       = 0.9241; rotation not taken.

Third     "               "               "       = 0.9430; rotation       "

The cineol, determined by the phosphoric acid method in the first fraction and calculated for crude oil, was 57 per cent. (O.M.) By the rapid phosphoric acid method, determined in February, 1920, the result was 64 per cent.

It will be seen from these results that the oil we distilled from *E. globulus*, growing naturally in New South Wales, was similar in character and constituents to those always obtained with the oil of this species, no matter where the trees are found growing naturally. This comparative constancy in the chemical product of identical species of Eucalyptus is one of the most interesting results brought to light by this research. This constancy in constituents is not peculiar to the oil of *E. globulus* alone, but is common to the several members of the genus, and innumerable instances of this fact are recorded in this work. It has been, we think, this constancy of constituents that enabled the oil of *E. globulus* originally to command such favourable consideration from those dealing in Eucalyptus oils. It is an illustration of the advisability of restricting operations to species the oils of which are in most request, and of keeping the product of individual species distinct. If this be done, then the quality of any Eucalyptus oil can be assured, and the industry become of greater importance, the species name being a guarantee of the constancy of the product; the purchaser could then be sure of obtaining what is required. That this method is a judicious one has been illustrated over and over again, more particularly, perhaps, with the oils of *E. Macarthuri*, *E. polybractea*, and *E. Australiana*. Nothing can be more detrimental than the indiscriminate mixing of oils of the various Eucalypts, and if more than one species belonging to the same chemical group are being worked, it would even then be better to keep the products distinct, although the oils may be in agreement. The advantages to be derived from such a procedure will be more fully recognised when cultivation of Eucalyptus species for their oil products shall become more general. *Eucalyptus globulus* belongs to a group of cineol-pinene oil yielding trees, of which many occur in Australia, the oils of which are often not easily distinguishable from each other. Commercially-distilled Eucalyptus oils ought, therefore, to be supplied with that constancy of constituents and physical characters which have so long been characteristic of the product of *E. globulus*. Very little oil of this species is now distilled in Australia, as the products of more prolific yielding species have supplanted it, the higher yields of oil of these species alone being answerable for this.





**EUCALYPTUS GLOBULUS, LABILL.**

TASMANIAN BLUE GUM.

(After Mueller.)



## 89. *Eucalyptus Nepeanensis*.

(Sp. nov.)

**Box.**

**Systematic.**—A medium-sized tree, with "Box" bark on the lower portions of the stem. Leaves lanceolate, but very variable in size, from broad lanceolate (2 inches broad and over 6 inches in length) to narrow lanceolate (2 lines broad and over 6 inches long), ovate, acuminate, under 4 inches long, dull or slightly shining, uniform green on both sides; venation distinct, lateral veins oblique, intramarginal vein removed from the edge, and especially so in the case of the broad lanceolate and ovate forms of the leaves. Peduncles axillary, 4 to 5 lines long, with six or more flowers in the umbel. Buds about 6 lines long, angular in the early stages. Calyx  $1\frac{1}{2}$  lines in diameter at the time of flowering, hemispherical; operculum hemispherical, acuminate,  $1\frac{1}{2}$  lines long.

**Fruit.**—Hemispherical to pyriform; rim flat or slightly countersunk; valves not exerted; under 3 lines in diameter.

*The fruits are not much unlike those of E. melliodora or E. Bosistoana, with which species it has the most affinity.*



**Habitat.**—Cabramatta, St. Marys, New South Wales.

**REMARKS.**—Since the publication of the "*Flora Australiensis*," it has been usual to place this species and *E. pendula* (both of Cunningham) under Mueller's *E. largiflorens*. With such a classification we do not agree, as Cunningham's specific names apply to interior species, whilst this is a coastal tree, with a pale-coloured whitish timber, "Box" barked only on the lower portion of the stem, and with erect branches and branchlets. In our first edition it was placed and fully described under *E. bicolor*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from St. Marys, N.S.W., in November, 1900. The yield of oil was 0.52 per cent. The crude oil was amber-coloured, and had an odour resembling those of the cineol-pinene class of Eucalyptus oils. It was rich in cineol; pinene was present, but phellandrene was absent. The oil also contained rather a large amount of the sesquiterpene, so that the specific gravity was somewhat high. Crystallised eudesmol was not detected.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9259; rotation  $a_D + 1.1^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4677, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.6.

On rectification, 2 per cent. distilled below  $171^{\circ}$  C. (corr.). Between  $171-183^{\circ}$ , 71 per cent. distilled; between  $183-245^{\circ}$ , 14 per cent. came over, and between  $245-269^{\circ}$ , 9 per cent. distilled. These fractions gave the following results:—

|                 |                         |           |                                 |
|-----------------|-------------------------|-----------|---------------------------------|
| First fraction, | sp. gr. at $15^{\circ}$ | = 0.9197; | rotation $a_D + 2.10^{\circ}$ . |
| Second          | "                       | = 0.9243; | " not taken.                    |
| Third           | "                       | = 0.9457; | "                               |

The cineol, determined by the phosphoric acid method in the first fraction, was 70 per cent. (O.M.), indicating about 56 per cent. in the original oil.



The above sample had been stored in the dark, and in September, 1919, was again analysed. Not much alteration had taken place during the nineteen years it had been kept. 78 per cent. distilled below  $190^{\circ}\text{C}$ . The crude oil and the redistilled portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}\text{C}$ . = 0.9276; rotation  $a_D + 0.5^{\circ}$ ; refractive index at  $20^{\circ} = 1.4682$ .

Rectified portion „ = 0.9219; rotation  $a_D + 1.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4606$ .

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 74 per cent. By the rapid phosphoric acid method it was 68 per cent. when calculated for the crude oil. Terpeneol was detected in the rectified portion.

## 90. *Eucalyptus cordata*.

(Labill., Pl. Nov. Holl., ii, 13, t. 152, 1806.)

**Systematic.**—A small glaucous tree or shrub, with a smooth, deciduous bark. Leaves opposite, thinly coriaceous, obcordate, broadly ovate, ovate-acuminate, crenate, 2 to 3 inches long; venation not distinctly marked, lateral veins oblique, spreading and looping some distance from the edge. Peduncles axillary, terete, about 3 lines long, with three sessile flowers in the umbel. Calyx conical to cylindrical, about 3 lines in diameter; operculum depressed-hemispherical, obtuse or umbonate, much shorter than the calyx tube.

**Fruit.**—Depressed-globular, of a bluish colour, contracted below the orifice; rim not thick, the capsule somewhat sunk; valves not exerted; about 6 lines in diameter.

*Fruits are distinct from any others, the nearest being some forms of E. goniocalyx.*



**Habitat.**—Recherche Bay and Huon River, Huon Road, head of Hobart Water Supply, Tasmania.

**REMARKS.**—This Eucalypt is peculiar to Tasmania. Its nearest ally in Australia is Sim's *E. pulverulenta*. The two, however, are quite distinct as recorded by Hooker, Sims, Robert Brown, and Bentham. Having visited Tasmania for the purpose of botanical investigation, we have now seen both trees in the field, and our observations quite agree with the classification of those botanists. This tree has an erect habit quite dissimilar to that of *E. pulverulenta*, with its "weak, green, almost clinging, stems." (*Vide* Note in this Work under *E. pulverulenta*.)

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Tasmania, in March, 1902. The yield of oil was 2.3 per cent.; this is a very high yield for an oil rich in cineol, so that this species may be considered as one of the best of the cineol-pinene class of Eucalyptus oils, which do not contain phellandrene. The crude oil was of an orange-brown colour, and had an odour resembling the cineol-pinene oils generally. Volatile aldehydes were present in some quantity, and altogether the oil resembled in general chemical characters, those derived from *E. pulverulenta* and *E. cinerea*. Cineol was the most abundant constituent in the oil; dextro-rotatory pinene was present, but phellandrene was absent. Esters were present in some quantity for an oil of this class, and in this resembled those of the species above mentioned.



W. Marshall, del.

EUCALYPTUS CORDATA, LABILL.

no small  
amounts



The crude oil had specific gravity at 15° C. = 0.9138; rotation  $\alpha_D + 8.5^\circ$ ; refractive index at 20° = 1.4638, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 14.85.

On rectification, 2 per cent. distilled below 162° C. (corr.). Between 162–183°, 83 per cent. distilled; and between 183–195°, 11 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9117; rotation  $\alpha_D + 8.75^\circ$ .

Second " " " = 0.9176; " "  $\alpha_D + 3.25^\circ$ .

The cineol, determined in the first fraction by the phosphoric acid method, was 62 per cent., or about 55 per cent. in the crude oil. (O.M.).

The above sample had been stored in the dark, and in February, 1920, was again analysed. The specific gravity had increased, as had also the cineol. 90 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9362; rotation  $\alpha_D + 8.1^\circ$ ; refractive index at 20° = 1.4643.

Rectified portion " " = 0.9225; rotation  $\alpha_D + 6.8^\circ$ ; refractive index at 20° = 1.4597.

The cineol was determined by the rapid phosphoric acid method in the rectified portion; when calculated for the crude oil the result was 65 per cent.

The oil was acetylated in the usual manner, when the saponification number had increased to 66, indicating the presence of about 12 per cent. of free alcohol.

## 91. *Eucalyptus Australiana*.

(R.T.B. & H.G.S., Proc. Roy. Soc., N.S.W., 1915, p. 514.)

### Black Peppermint.

**Systematic.**—It attains forest tree height, but more often is only a medium sized tree. The bark is persistent well out on the branches, and is typically "peppermint," being of a compact, fibrous nature. Abnormal leaves sessile, opposite, cordate-lanceolate. Normal leaves narrow, lanceolate; venation distinct, lateral veins very oblique, intramarginal vein removed from the edge. Peduncles axillary, with about ten to twenty flowers; calyx turbinate, short; operculum obtuse, flattened.

**Fruit.**—Pilular to turbinate, rather small, comparatively; with red rim, countersunk when fully ripe, and a thin contracted edge; valves not exerted; from 2 to 3 lines in diameter.



*The insloped rim is perhaps the best feature by which to separate these fruits from those of E. amygdalina, but their shape differs very little, if any, from E. amygdalina, var. nitida, and E. phellandra.*

**Habitat.**—Yourie, Reedy Creek, Tanto, Nerrigundah, as far south as Wyndham, Burruga and Black Springs, Bathurst district, all in New South Wales.

**REMARKS.**—This is an addition to our former book on the subject, the species not having been discriminated at that time. It was described before the Royal Society, New South Wales, vol. 49, p. 514, as a new species, as the result of our work on the Eucalypts of Tasmania, when it was stated that *E. amygdalina*, a species under which this tree has been grouped in the past, was restricted to that Island, and did not occur on the mainland as previously supposed. It is hoped that the separation of this and one or two Eucalypts from those previously named as *E. amygdalina* will lead to clearing up the confusion, both botanically and chemically, that has been so prominent in the past.

**ESSENTIAL OIL.**—The production of an excellent pharmaceutical Eucalyptus oil from this species depends largely upon a fact which was recorded in the first edition of this work, 1902, p. 170. We there showed that by fractional separation at stated times during the primary distillation, an oil richer in cineol could be obtained, particularly if the portion which came over during the first hour were separated. The cineol in this way was more easily obtained than were the alcoholic bodies and other higher boiling constituents in the leaf. By taking advantage of this property, and working the trees growing at Nerrigundah, Yourie, and neighbouring districts of New South Wales in this way, it has been possible to produce an oil of a fairly constant character, high in cineol content, and conforming readily to the requirements demanded for a first-class pharmaceutical Eucalyptus oil. The results have been so satisfactory that the species is, at the above localities, now worked in this way, the "first hour oil" being sold for pharmaceutical purposes, the remainder being employed for mineral separation and for other industrial uses. The chemical results obtained with this oil, separated as nearly as possible one hour after commencing to distil, are remarkably constant, so much so that it is not difficult to decide whether the time of separation had been extended beyond the hour. (See the article "The comparative constancy of the oil products from individual species of Eucalyptus.")

The remarkably high yield of oil given by this species enables this method of working to be profitably undertaken, and the quantity of oil obtained during the first hour is as great as that from many other cineol producing species when these are distilled right out. The "second hour oil" thus becomes practically a subsidiary product, and as it contains a good quantity of terpineol with some geraniol, finds uses in other directions. Little advantage appears to be derived from distilling the leaves for a longer period than two hours, as the amount of oil obtained is but small. The "first hour oil" when properly prepared, is water-white, which fact appears to be due to the presence of the liquid phenol, Tasmanol—common to this group of Eucalypts. This phenol contains a methoxy group, a constitution which does not tend to the formation of a yellow colour, as is the case with the crystallised phenol occurring in the oils of other large classes of cineol producing Eucalypts. The amount of volatile aldehydes in the crude oil is but small, so that rectification of the "first hour oil" is not necessary before placing it on the market. This species of Eucalyptus, considered as a cineol oil producing tree, thus becomes of considerable importance from an industrial point of view, particularly as the country where it grows plentifully is usually of little value for agricultural purposes.

Our attention was first directed to an increased amount of cineol in the oil of the "Narrow-leaved Peppermint" growing in the Southern Coast District of New South Wales, by Mr. W. T. Farrell, early in 1913. He had collected his specimens at Nerrigundah, in which locality this tree occurs somewhat abundantly. Arrangements were made to distil the oil in commercial quantities, and control analyses were undertaken at the Technological Museum, on the oil collected each month. In November of that year the Museum Collector forwarded material from Yourie and Tanto, in the Cobargo district. This was distilled at the Museum, and the results of the analysis of the oil are here given. Later, a visit was paid to this portion of New South Wales, and by the courtesy of the District



Forester at Moruya, Mr. Clulee, and his assistant, Mr. Harrison, who drove his car, it was possible to make extensive observations over a considerable area of country, concerning this Eucalypt. Since that time numerous analyses of the oil have been made for distillers, who have prepared the oil for market, and quite an industry has now been established in the production of this particular Eucalyptus oil, and large quantities have already been sold.

The determination of rotations so far made, have shown the "first hour oil" to be usually slightly dextro-rotatory, although if the distillation be continued longer, the resulting oil may be slightly lævo-rotatory. This result appears to be due to the presence of some terpineol. Improvements in this method of first distillation will result in the production of a pharmaceutical oil from this species growing in other localities, and already at Burruga, in the Bathurst district, it is being so worked for pharmaceutical oils. An analysis of the oil from this district is given later.

In the first edition of this work, p. 275, we drew attention to some remarkable features shown by the oils of this group, particularly that of solubility in 70 per cent. alcohol, a result which placed the species in the class yielding Eucalyptus oils richest in cineol, thus practically predicting the present results. This high solubility is due to the presence of the alcohols terpineol and geraniol as well as to the cineol. That this is so is shown by the increased saponification numbers of the acetylated higher-boiling fractions, as well as from the results with the Nerrigundah "second hour oil."

*Yield of Oil.*—The yield of oil from the Yourie-Tanto material agrees with that of this species from other localities, and our sample, distilled at the Museum, gave 4.4 per cent. for leaves with terminal branchlets, collected in the month of November. The material, which had dried somewhat, was weighed into the still and the amount of oil determined. These figures may perhaps be considered as the maximum yield. From a series of results obtained by Mr. E. McGrath, of Yourie, during the months of June, July, August, September and October, the differences of yield at various times of the year are well illustrated. Mr. McGrath uses a pair of tanks coupled together and worked simultaneously. These are the usual 400-gallon square iron tanks, fitted in the simple manner customary with the majority of Eucalyptus oil distilling plants in New South Wales, and fired directly.

Average yield of oil from the two tanks for all distillations.

| For the Month of | "First Hour Oil." | "Second Hour Oil." | Average per tank. |
|------------------|-------------------|--------------------|-------------------|
| June ... ..      | 28 lb.            | 12 lb.             | 20 lb.            |
| July ... ..      | 37 lb.            | 11 lb.             | 24 lb.            |
| August ... ..    | 39 lb.            | 12 lb.             | 25½ lb.           |
| September ... .. | 42 lb.            | 12 lb.             | 27 lb.            |
| October ... ..   | 41 lb.            | 11 lb.             | 26 lb.            |

The months of June and July are midwinter in Australia, when the oil is at a minimum.

The actual weight of green leaves with terminal branchlets packed into the tanks was not known, but if this be considered as 800 lb. per tank, which amount would probably be nearly correct, then for June an average yield of 2.5 per cent. was obtained: for July 3 per cent., for August 3.2 per cent., for September 3.4 per cent., and for part of October 3.3 per cent.



*Analysis of the Oil.*—The crude oil of the Yourie and Tanto material distilled at the Technological Museum, was of a very light lemon tint, had quite a pleasant odour, the volatile aldehydes not being at all pronounced. The oil contained a large amount of cineol. The reaction for phellandrene was not distinctive, and this terpene probably does not occur in the oil of this species at any time except in traces.

The crude oil, which had been distilled right out, had specific gravity at  $15^{\circ}\text{C.} = 0.9157$ ; rotation  $a_D + 2.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4644$ ; and was soluble in 1.2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.9.

On rectification, 2 per cent. distilled below  $172^{\circ}\text{C. (corr.)}$ . Between  $172\text{--}193^{\circ}$ , 84 per cent. distilled; between  $193\text{--}220^{\circ}$ , 5 per cent. distilled, and between  $220\text{--}260^{\circ}$ , 5 per cent. distilled. These fractions gave the following results:—

|                                  |                                                                                                                        |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------|
| First fraction,                  | sp. gr. at $15^{\circ}\text{C.} = 0.9119$ ; rotation $a_D + 2.7^{\circ}$ ; refractive index at $20^{\circ} = 1.4623$ . |
| Second     ,,     ,,     ,,      | $= 0.9165$ ; rotation $a_D + 0.8^{\circ}$ ; refractive index at $20^{\circ} = 1.4679$ .                                |
| Third       ,,       ,,       ,, | $= 0.9380$ ; rotation $a_D + 0.6^{\circ}$ ; refractive index at $20^{\circ} = 1.4861$ .                                |

The cineol was determined by the resorcinol method in the first fraction, and calculated for the whole oil; the result for the crude oil was 70 per cent. By the phosphoric acid method it was 66 per cent. The higher fraction contained a little piperitone (the constituent of peppermint odour), a small amount of ester, and free alcohols. A portion of the crude oil was then acetylated in the usual manner, when the saponification number had risen to 51.3. This result indicated the presence of alcohols in fair quantity, to which constituents the aromatic and somewhat characteristic odour of the oil was largely due. As the alcohol was chiefly terpineol there was about 12 per cent. of that constituent in the crude oil, assuming the whole alcohol to be that substance. The presence of the terpineol is more distinctly shown with the second and third hour oils, which were distilled and collected for us by Mr. Gough, of Yourie. Geraniol is also a constituent in the oil of this species.

*"First Hour Oil."*—As previously mentioned, the commercial distillation of this species has resolved itself into a fractional separation during the primary distillation of the oil from the leaf.

The "first hour oil" is practically water-white, as are all the rectified oils of this group; it is rich in cineol, of good odour, and is fairly constant in composition. The average specific gravity of the "first hour oil" taken by Mr. McGrath for twenty-six distillations during the months of September and October was 0.919, the highest being 0.920, the lowest 0.917.

For the constants with the "first hour oil," see the table in the article "The comparative constancy of the oil products from individual species of Eucalypts."

Numerous analyses of this "first hour oil" have been made at the Technological Museum, beyond those enumerated in the table mentioned above. They were, however, all in agreement, so that it is unnecessary to tabulate them further. It may be stated, however, that the solubility in alcohol in no case exceeded 1.1 volumes 70 per cent. alcohol, and that they all contained about 70 per cent. of cineol, determined by the phosphoric acid method. (See also an analysis under the quantitative determination of cineol.)



EUCALYPTUS AUSTRALIANA, R.T.B. & H.G.S.

BLACK PEPPERMINT.

70. 1941  
1941.1941





**A TYPICAL PEPPERMINT BARK.**

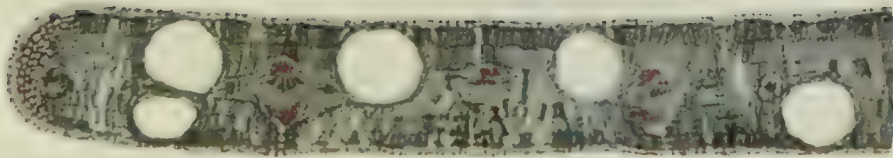
*Eucalyptus Australiana*, R.T.B. & H.G.S.

These barks might be described as a fine lattice pattern, and rather closer in texture than those of the "Stringybarks," but shorter in the fibre, and the colour more bordering on that of the "Boxes."

The chief constituents in the oils of Eucalypts with bark of this character are cineol, phellandrene and piperitone. These constituents vary in amount in the several species.

The "Peppermints" apparently represent the later species of the genus.

70 1000  
ALPHABETIC



A cross section towards the leaf margin. The large yield of oil of this species is here indicated by the number and comparatively large oil glands in such a limited area. This leaf is of a rather delicate nature in the case of both the mesophyll and palisade parenchyma, the latter being more developed towards the upper surface. The strengthening tissue backing the outer edge of the leaf is not well developed.

x 70.

THE  
CALIFORNIA

EUCALYPTUS AUSTRALIANA, R.T.B. & H.G.S.





The resorcinol determinations for the cineol were always taken with the fractionated oil in the portion distilling below  $190^{\circ}$  C., and calculated for the crude oil. The results would be altogether too high if taken with the commercial sample directly, because terpineol and other bodies are also absorbed; even in the portion distilling below  $190^{\circ}$  C., substances other than cineol are absorbed by the resorcinol, and the results are consequently too high when determined in this way.

The specific gravities were in all cases corrected for  $15^{\circ}$  C., the factor 0.00075 being employed for that purpose.

*"Second Hour Oil."*—A sample of the "second hour oil" was forwarded to us by Mr. C. Gough, of Yourie, and was portion of the "second hour oil" he had commercially distilled. It was but little coloured, and had quite an aromatic odour. It had specific gravity at  $15^{\circ}$  C. = 0.9291; rotation  $\alpha_D + 2.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4720; and was soluble in 1.1 volumes 70 per cent. alcohol. On distillation, 64 per cent. came over between  $172^{\circ}$  and  $193^{\circ}$  (corr.). This fraction had specific gravity at  $15^{\circ}$  = 0.9131; rotation  $\alpha_D + 3.3^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4655, and contained 31 per cent. cineol by the phosphoric acid method, representing 20 per cent. in the "second hour oil." 25 per cent. came over as the second fraction, boiling between  $193^{\circ}$  and  $227^{\circ}$ . This had a specific gravity at  $15^{\circ}$  = 0.9283; rotation  $\alpha_D - 0.2^{\circ}$ ; and refractive index at  $20^{\circ}$  = 1.4760.

The saponification number for the esters in the "second hour oil" was 11.4, while in the acetylated oil it was 95.1. This latter figure represents 33 per cent. of ester if calculated for a  $C_{10}H_{17}OH$  alcohol, and if considered to consist wholly of terpineol, there was 23 per cent. of that substance, at least, in the free condition in the "second hour oil."

*"Third Hour Oil."*—A sample was also forwarded by Mr. Gough. It showed but slight chemical differences from the oil of the second hour, except that the alcohol was a little more pronounced. It had specific gravity at  $15^{\circ}$  C. = 0.9266; rotation  $\alpha_D + 2.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4747, and was soluble in 1.1 volumes 70 per cent. alcohol. Addition of more alcohol determined the presence of paraffin in both the second and third hour oils. The saponification number for the ester plus that of the free acid was 9.7; while with the acetylated oil it was 116.03; representing 29.4 per cent. of free terpineol in the "third hour oil."

On distillation, 55 per cent. came over below  $193^{\circ}$  C., and 35 per cent. between  $193^{\circ}$  and  $225^{\circ}$ . 26 per cent. of cineol was found to be present in the first fraction, determined by the phosphoric acid method. The specific gravity of the first fraction at  $15^{\circ}$  C. = 0.9145; and refractive index at  $20^{\circ}$  = 1.4669. The second fraction had specific gravity at  $15^{\circ}$  = 0.9267; rotation  $\alpha_D - 1.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4770. The saponification number for the ester plus that of the free acid was 9.4. A portion of the second fraction of the "third hour oil" was acetylated, when the saponification number had increased to 124.5. This represents an ester percentage of 43.6, indicating 31.7 per cent. of free terpineol at least in this portion. (For the determination of the Terpineol, see the article on that substance in this work.)

In February, 1920, through the kindness of Mr. R. H. McNeice, we received material of this species for distillation, from Black Springs, a locality

about ten miles from Oberon, N.S.W. The yield of oil was 3.3 per cent. The crude oil was of a pale yellow colour, and had a pleasant odour with a secondary one of citral. Phellandrene was not detected.

The constitution of the oil was quite in accord with that distilled from the Yourie material above, although the distance separating the two localities is about 200 miles.

The crude oil, which was distilled right out, had specific gravity at 15° C. = 0.9141; rotation  $a_D + 5.4^\circ$ ; refractive index at 20° = 1.4634, and was soluble in 1.2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 10. After acetylation this had risen to 47.7; while in the cold with two hours' contact it was 15.8.

On rectification, 1 per cent. distilled below 172° C. (corr.). Between 172–193°, 92 per cent. distilled, and between 193–235°, 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9106; rotation  $a_D + 5.3^\circ$ ; refractive index at 20° = 1.4614.

Second „ „ „ = 0.9170; rotation  $a_D + 3.2^\circ$ ; refractive index at 20° = 1.4684.

The cineol was determined by the resorcinol method in the first fraction; when calculated for the crude oil the result was 67 per cent. By the rapid phosphoric acid method it was 64 per cent. when calculated for the crude oil. The alcohols present were geraniol and terpineol, as in the oil from the Yourie material.

*The Citral.*—The secondary odour of the oil of the Black Springs sample was distinctly that of citral. To determine the identity of this aldehyde 1,000 c.c. of the crude oil were distilled, and all boiling below 190° C. removed. The remainder was agitated with neutral sodium sulphite until the reaction was complete. The aqueous portion was washed with ether, decomposed with sodium hydrate, again extracted with ether, and on removal of this solvent 2.5 c.c. of an aldehyde remained, equal to 0.25 per cent. This had an odour of citral, and gave the following figures:—Specific gravity at 15° C. = 0.894, was inactive to light; had refractive index at 20° = 1.4875, and the  $\beta$ -naphthocinchonic acid melted at 199–200° C. These constants are those for citral. It was probably derived from the natural oxidation of the geraniol, which alcohol is a constant constituent in the oil of this species.

## ***Eucalyptus Australiana*, (R.T.B. & H.G.S.) var. *latifolia* (nobis).**

**Systematic.**—This appears to be the most southern form of the species, and is distinguished from its type by the broad leaves and larger shining fruits. These two latter features greatly resemble those of *E. dives*, especially the fruits; the venation of the leaves easily shows it not to be that species. It is figured under *E. amygdalina* in the first edition. The abnormal leaves are large, cordate, sessile, acuminate; the venation well marked, the marginal vein being well removed from the edge. The normal leaves are long, up to 9 inches in length, broad lanceolate, intramarginal vein well distant from the edge.

**Habitat.** —Officer, Victoria; Moruya, N.S.W.



**ESSENTIAL OIL.**—Material for distillation was received from Officer, Victoria, in 1900, but as the results could not be specifically placed at that time they were omitted in the first edition. On the discovery of *E. Australiana*, however, they fall into line, and are now published. The yield of oil was 2 per cent. The crude oil was but little coloured, and had a secondary odour of citral. It was fairly rich in cineol and contained, at that time of the year, traces of phellandrene. It had specific gravity at 15° C. = 0.9155; rotation  $a_D$  — 1.9°; refractive index at 20° = 1.4662 and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.

On rectification, 1 per cent. distilled below 174° C. (corr.). Between 174–183°, 78 per cent. distilled, and between 183–225°, 16 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9097; rotation  $a_D$  — 2.5°.

Second „ „ „ = 0.9187; „ — 0.8°.

The cineol, determined in the crude oil by the phosphoric acid method, was 50 per cent. (O.M.).

In 1917 Mr. A. R. Penfold investigated the oil from this species growing near Moruya, N S.W. The analysis gave results quite in agreement with those recorded above.

## GROUP IV.

## CLASS (a).

In this Group are placed the following EUCALYPTS yielding an oil containing over 40 per cent. of cineol, but in which pinene is diminishing and aromadendral\* making its appearance, thus approaching the typical "Boxes." Phellandrene is absent.

- 92. *Eucalyptus elæophora.*
- 93. *E. punctata.*
- 94. *E. tereticornis*, var. *cineolifera.*
- 95. *E. cosmophylla.*
- 96. *E. stricta.*
- 97. *E. oleosa.*
- 98. *E. dumosa.*
- 99. *E. polybractea.*
- 100. *E. cneorifolia.*
- 101. *E. odorata.*

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\*The name Aromadendral is used throughout this work in a general sense to denote the presence of one or more members of this group of characteristic aldehydes, which includes cuminaldehyde and cryptal. See the article in this work on these aldehydes.

## 92. *Eucalyptus elæophora*.

(F.v.M., Frag., iv., 1863-64, p. 52.)

**Bundy or Half Box.**

**Systematic.**—A rather low stunted tree with a somewhat fibrous bark, resembling that of *E. Bridgesiana*. Abnormal leaves vary much in size and shape, being sometimes orbicular, or even broader than long, and sessile, 6 inches broad and 4 inches long, or when petiolate they are ovate, cordate, coriaceous, acuminate, or obtuse, not shining, mealy, coriaceous; in the sessile leaves the venation is very strongly marked, the circumferential vein sometimes  $\frac{1}{2}$  inch from the edge. The venation in the petiolate form of the young leaves is only faintly marked, the intramarginal vein being removed from the edge; a dull green on both sides, mealy or glaucous, 3 to 4 inches long. This latter form of leaf is mostly found on the square abnormal branchlets. The normal leaves are lanceolate in shape, acuminate, not shining, lateral veins fine, numerous; the intramarginal vein close to or not far removed from the edge. Peduncles axillary, 3 lines long, thick, flattened, bearing five to seven flowers. Calyx cylindrical or angular, under 2 lines long; operculum short, obtuse.

**Fruit.**—Sessile, almost hemispherical, slightly ribbed at the base; rim narrow, with a groove below it; valves sunk or just exserted; 4 lines long and 3 to 4 lines in diameter.



*In shape these fruits are almost a facsimile of E. Gunnii, E. pulverulenta, E. cinerea, or E. unialata.*

**Habitat.**—Victoria, and throughout the central districts of New South Wales.

**REMARKS.**—This tree as *E. elæophora*, F.v.M., was described by Baron von Mueller in his *Fragmenta Phytographiæ Australiæ*, Vol. IV, p. 52 (1863-4), under the impression that it was distinct from his original *E. goniocalyx*, described some years previously (1859). Bentham, however, in his *Flora Australiensis*, Vol. III, p. 230, places *E. elæophora* with *E. goniocalyx*, and Baron von Mueller in his *Eucalyptographia* concurs in this synonymy. Bentham's results were founded on herbarium specimens, and as recent experience has shown that Eucalypts cannot be determined on such material alone, one can readily understand *E. elæophora* being regarded as a variety of *E. goniocalyx*. Mueller's original descriptions (*loc. cit.*) of the two species in our opinion, show clearly that two distinct trees are referred to, and it is therefore rather difficult to understand why he accepted Bentham's diagnosis, as he probably found a difficulty in reconciling it with his previous work, for in combining the two under his description of *E. goniocalyx* in his *Eucalyptographia*, he states, *inter alia*, "as regards the nature of the bark, it fluctuates between the groups *hemiphloia* and *leiophloia*, in the latter case the tree passes among the woodmen as 'Blue' and 'White Gum,' in the other case, as 'Grey' or 'Bastard Box.' . . . the above-quoted synonym (*E. elæophora*) pertains to the variety with more persistent bark." The "Grey" or "Bastard Box," is, therefore, his *E. elæophora*, and as its timber is almost worthless, the two trees from this one point alone cannot be placed under the same species, particularly from an economic point of view. The bark distinguishes it also from *E. goniocalyx*, as well as the buds, fruits, leaves, and oil. Bentham was probably led to unite the species owing to the similarity of calyx, anthers, and fruits (partly); but Mueller's concurrence in the suppression of his species was probably owing to his want of knowledge of the trees in their native habitat, for had he so seen the trees, one could hardly think that he would have approved of Bentham's arrangement. This tree was restored to specific rank (Proc. Linn. Soc., N.S.W., 1900), by Messrs. Deane and Maiden, under the name of *E. Cambagei*, but has since been suppressed, and given its original rank of *E. elæophora*, by Maiden, Crit. Rev., Vol. II, p. 275. It has affinities with *E. Bridgesiana*, R.T.B., having a light-coloured, open-grained timber, with a "Box" bark.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Bungendore, N.S.W., in March, 1899. The yield of oil was 0.84 per cent. The crude oil was reddish-brown in colour, and had an odour resembling those of the cineol-pinene oils generally. It was very rich in cineol. Pinene





The above samples were mixed together, stored in the dark, and in September, 1919, the oil was again analysed. The specific gravity had increased somewhat during the 20 years it had been kept, and the cineol had also increased in amount. This is well shown by the constants obtained with the rectified oil. The crude oil and the rectified portion gave the following results. 84 per cent. distilled below  $190^{\circ}\text{C.}$  :—

Crude oil, sp. gr. at  $15^{\circ}\text{C.} = 0.9518$ ; rotation  $a_D + 4.9^{\circ}$ ; refractive index at  $20^{\circ} = 1.4657$ .

Rectified portion „ „ „ =  $0.9267$ ; rotation  $a_D + 3.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.4596$ .

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 79 per cent. By the rapid phosphoric acid method it was 66 per cent., when calculated for the crude oil. Terpeneol was detected in the rectified portion.

We have described somewhat fully the various samples of oil obtained from this species, as the localities enumerated cover a large area, and the time extends over some years. The results show how closely related are the chemical constituents of the products of a particular species of *Eucalyptus*, irrespective of location or environment.

### 93. *Eucalyptus punctata*.

(DC., Prod., iii, 217.)

Grey Gum.

**Systematic.**—A large tree, with a dirty looking, smoothish, or friable bark, and rectangular branchlets. Abnormal leaves ovate, lanceolate, often shortly acuminate, 4 to 6 inches long, pale coloured on the underside, sometimes almost oblique, membranous, margins recurved; venation distinct, oblique, spreading. Normal leaves lanceolate, sometimes oblique, pale on the underside, varying in length and breadth up to 6 inches and 2 inches respectively, thinly coriaceous; venation not pronounced, lateral veins fine, oblique, parallel, intra-marginal vein close to the edge. Peduncles axillary, flattened, under 6 lines long, about six flowers in the umbel. Calyx in the bud stage angular, conical; in the flower stage hemispherical; operculum conical or hemispherical, and much acuminate, under 3 lines long.

**Fruit.**—Turbinate to hemispherical, pedicel thick, short; rim thick, domed; valves obtuse, well exerted and pale; 4 lines in diameter.

*They are quite specific; the dark slightly domed rim is the more common and easily distinguished, but occasionally the rim is truncate, giving the capsule an E. resinifera appearance.*



**Habitat.**—Coast districts of New South Wales and Queensland.

**REMARKS.**—This is one of the best-known trees in the neighbourhood of Sydney, where its common appellation is "Grey Gum." The bark is characteristic, and although classed as smooth, yet is perhaps the dirtiest looking bark to be found amongst the smooth-barks or Gums. In the older trees it becomes dark, rugose, variegated, and exudes manna (H. G. Smith; see Paper in Proc. Roy. Soc., N.S.W., Vol. 31, p. 177), as well as the leaves. The mountain varieties are separated under the varietal names of *didyma* and *major*.



**ESSENTIAL OIL.**—During the months of May and June, 1897, a somewhat extensive investigation was undertaken on the oil of this species, and considerable material distilled, which had been collected from individual trees in various stages of growth. The results with the different samples of oil obtained during that investigation will be found tabulated in a later article. The results of this investigation were first submitted by us to the Royal Society of New South Wales, and are published in the proceedings XXXI, p. 259. All the oils contained similar constituents, and these only varied slightly in amounts, this variation accounting for the slight differences in physical properties. With general material even these slight alterations would be minimised and a closer uniformity in general characters observed. The oil of this species of *Eucalyptus* was rich in cineol, contained pinene, but phellandrene was absent. Aromadendral was present in small amount in the various samples, but was a little more pronounced in some than in others.

To arrive at the constitution and general character of the oil of this species, equal volumes of the crude oils of all the samples were mixed together, and the resulting product analysed. The mean yield of oil from all the material was 0.8 per cent. This crude mixed oil had specific gravity at  $15^{\circ}\text{C.} = 0.9160$ ; rotation  $a_D + 0.85^{\circ}$ ; refractive index at  $20^{\circ} = 1.4717$ , and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 18.8.

On rectification 1 per cent. distilled below  $167^{\circ}\text{C.}$  (corr.). Between  $167-172^{\circ}$ , 30 per cent. distilled; between  $172-183^{\circ}$ , 58 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.910$ ; rotation  $a_D + 2.15^{\circ}$ .

Second „ „ „ „ =  $0.9156$ ; „ „ „ „ +  $1.1^{\circ}$ .

The cineol, determined by the phosphoric acid method in the second fraction, was 62 per cent., and in the crude oil 55 per cent. (O.M.).

The rectified oil was slightly tinged yellow, a character usual with the oils of this group, and is apparently due to the influence of the predominant phenol present in these oils.

The material from which the several oils were distilled was collected from (a) one fair-sized tree; (b) one large tree; (c) abnormal leaves; (d) from a large tree; (e) from old trees mixed; (f) from young trees 20–30 feet high, mixed; (g) from medium trees mixed; (h) from one medium-sized tree; (i) from one very fine tree, the leaves of which were divided into two equal parts and distilled separately. All the above material was collected near Sydney.

The whole of the oils distilled for the above investigation were mixed together, a portion kept in the dark, and in September, 1919, twenty-two years afterwards, this oil was again analysed. It had not altered much during that long period, except that the specific gravity was a little higher, but the cineol apparently had not increased in amount. On rectification 82 per cent. distilled below  $190^{\circ}\text{C.}$  The crude oil and large fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}\text{C.} = 0.9337$ ; rotation  $a_D + 0.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4724$ .

Large fraction „ „ „ „ =  $0.9147$ ; rotation  $a_D + 1.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4639$ .

The cineol was determined by the resorcinol method in the large fraction and calculated for the crude oil; the amount was 65 per cent. By the rapid phosphoric acid method it was 55 per cent., when calculated for the crude oil.





*EUCALYPTUS PUNCTATA*, D.C.

GREY GUM.



## 94. *Eucalyptus tereticornis*, Sm., var. *cineolifera* (nobis).

Red Gum.

**Systematic.**—A tree attaining a height of 80 feet and over, 2 feet in diameter, with a smooth, yellowish bark, blotched with dark-brown patches. Normal leaves coarse, broad-lanceolate to lanceolate, thick, coriaceous, often falcate, acuminate, usually under .6 inches long and 2 inches broad; sometimes abnormally narrow-lanceolate, more acuminate and thinner in texture; venation fairly distinct, intramarginal vein looped and much removed from the edge, lateral veins distant, irregularly branched, anastomosing and scarcely parallel. Peduncles axillary or lateral, angular, about 5 lines long, bearing umbels of five to seven flowers. Buds shortly pedicellate; calyx tube turbinate,  $1\frac{3}{4}$  lines long; operculum conoidal, sometimes slightly curved, 4 lines in length on pedicels 1 to 2 lines long.

**Fruit.**—Hemispherical, shining, wrinkled, domed; the rim continuing the curve of the lower portion of the fruit; valves well exerted and expanded; 2 lines long and  $2\frac{1}{2}$  lines in diameter.



*Scarcely any difference exists between the shape of these fruits and its type.*

**Habitat.**—Armidale, Marulan, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were received from Marulan, N.S.W., in July, 1898. The yield of oil was 0.9 per cent. The crude oil was red in colour and had an odour similar to those of the cineol-pinene oils in which aromadendral occurs. The oil was somewhat rich in cineol, thus differing from that of *E. tereticornis* itself. It also contained much less aromadendral. These two oils are analogous with those of *E. punctata* and *E. punctata* var. *didyma*, although reversed in the former case. The oil of *E. tereticornis* var. *cineolifera* contains pinene but not phellandrene. Esters were not pronounced, nor were volatile aldehydes present but in small amount. The oil contained some sesquiterpene.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9112; rotation  $a_D + 0.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4703, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.7.

On rectification, 1 per cent. distilled below  $168^{\circ}$  C. (corr.). Between  $168-183^{\circ}$ , 74 per cent. distilled; between  $183-250^{\circ}$ , 10 per cent. came over, and between  $250-265^{\circ}$ , 9 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.9022; rotation  $a_D + 2.1^{\circ}$ .

Second     ,,     ,,     ,,     = 0.9071;     ,,      $a_D - 3.0^{\circ}$ .

Third     ,,     ,,     ,,     = 0.9341;     ,,     too dark.

The cineol was determined by the phosphoric acid method in the portion boiling below  $183^{\circ}$ ; the result indicated 45 per cent. in the crude oil (O.M.). The lævo-rotation was due to the aromadendral.



Material for distillation was also received from Armidale, N.S.W., in June, 1907. The yield of oil was 0.94 per cent. The crude oil was red in colour, and had an odour similar to those of the cineol-pinene oils containing aromadendral. The oil was quite in agreement with that from Marulan, above, and contained the same constituents in practically the same amounts, except that it was a little richer in cineol.

The crude oil had specific gravity at 15° C. = 0.9075; rotation  $\alpha_D + 1.5^\circ$ ; refractive index at 20° = 1.4679, and was soluble in 1½ volumes 70 per cent. alcohol.

The cineol was determined by the phosphoric acid method in the crude oil; the result was 57 per cent.

## 95. *Eucalyptus cosmophylla*.

(F.v.M., in Trans., Vict. Inst., 32, 1855.)

**Systematic.**—A shrubby tree, though sometimes found up to 50 feet in height. Bark smooth (decorticating in thin flakes or sheets). Abnormal leaves broad, oval-cordate, sessile, crenulate, scabrous, branchlets much flanged. Normal leaves ovate-lanceolate, acuminate, pale green on either side; intra-marginal vein well removed from the edge, lateral veins generally at an angle of 45° with the midrib. Buds large, usually three, sessile or almost so, common peduncle flattened; calyx tube conical, rough, often ridged, about 5 lines long; operculum almost hemispherical, shortly pointed.

**Fruit.**—Semi-ovate, almost hemispherical, occasionally ribbed; rim bevelled or flat, outer edge sometimes forming into a flange; valves depressed or slightly exerted; about 6 lines long and 6 lines broad.

*In the larger form the fruit resembles those of E. longifolia, but the hemispherical more closely perhaps those of E. ovata, Labill., Western Australia, collected by Mueller.*



**Habitat.**—Kangaroo Island and ranges near Adelaide, South Australia.

**REMARKS.**—This species is endemic to South Australia, and is easy of determination, both in the herbarium and field, by its specific characters.

**ESSENTIAL OIL.**—Material consisting of the leaves and terminal branchlets for distillation was received from the Conservator of Forests of South Australia, Mr. Walter Gill. The material was collected in December, 1911. The yield of oil was 0.62 per cent. The crude oil was light orange-brown in colour, with an odour indicative of an oil belonging to the cineol-pinene group, with a secondary one suggestive of the aldehyde aromadendral. The presence of volatile aldehydes was particularly marked. The slight lævo-rotation of the

crude oil was evidently due to the aromadendral, although the pinene was also lævo-rotatory to a small extent; phellandrene was absent. This left rotation is unusual with oils of this class, as in most cases the pinene shows a predominant dextro-rotation. The cineol content was only fair, and the oil did not contain constituents having special characters; the species has, therefore, little value as an oil-producing tree.

The crude oil had specific gravity at 15° C. = 0.9108; rotation  $a_D$  — 3.2°; refractive index at 20° = 1.4659, and was soluble in 7 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.6.

On rectification, a few drops of acid water, together with some aldehydes, came over below 167° (corr.). Between 167–172°, 9 per cent. distilled; between 172–198°, 75 per cent. came over, and between 198–270°, 11 per cent. distilled. These fractions gave the following results:—

|                             |                                                                                      |
|-----------------------------|--------------------------------------------------------------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8909; rotation $a_D$ — 2.6°; refractive index at 20° = 1.4612. |
| Second     ,,     ,,     ,, | = 0.9065; rotation $a_D$ — 3.0°; refractive index at 20° = 1.4628.                   |
| Third     ,,     ,,     ,,  | = 0.9296; rotation $a_D$ — 3.3°; refractive index at 20° = 1.4827.                   |

The cineol was determined by the resorcinol method in the rectified portion, and calculated for the crude oil; the result was 50 per cent. By the phosphoric acid method it was 43 per cent. when calculated for the crude oil.

The rectified oil was tinged yellow, a peculiarity common with the oils of this group. This colour is traceable to quinone influence, derived from the phenol present in the oils of certain groups of the cineol class, but is not shown by the oils from the "Peppermints" or the "Ashes."

The results obtained with the oil of this species were published by us in the Trans. Roy. Soc., South Australia, 1916.

## 96. *Eucalyptus stricta*.

(Sieb., in DC. Prod., iii, 28, Mem. Myrt., t. 8.)

**Systematic.**—A shrubby species with linear-lanceolate, shining leaves, of a leathery texture and the veins scarcely visible, but upon removing the cuticle the exposed venation resembles that of the group to which *E. Smithii* (R.T.B.) belongs. Peduncles short axillary, with five to eight rather small flowers in the umbel. Calyx small, under 2 lines in diameter, gradually tapering into a thick pedicel; operculum hemispherical, shortly acuminate.

**Fruit.**—Oblong, shining, contracted at the thin rim; capsule sunk; valves not exserted; under 6 lines long.

*Great care is required not to confound these with those of E. obtusiflora and E. apiculata.*

**Habitat.**—Blue Mountains and Clyde District, New South Wales.





**REMARKS.**—This species occurs on the Blue Mountains, forming low scrub along with *E. obtusiflora*. The thick narrow leaves with their almost invisible veins, the smaller fruit, differently shaped buds, and the valuable oil obtainable from the leaves distinguish it from that species. It is probably the *E. dumosa*, A. Cunn., of the Blue Mountains, mentioned by Bentham, Fl. Aust. ii, p. 230, as that species does not occur in the Coastal Ranges of N.S.W. The "Mallee" at Berrima coal-mine, morphologically similar to *E. stricta*, Sieb., differs from the Blue Mountain *E. stricta*, in the chemical constituents of its oil, and the venation of the leaves, and is here regarded as a separate species, under the name of *E. apiculata*, R.T.B. & H.G.S.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Wentworth, N.S.W., in May, 1899. The yield of oil was 0.5 per cent. The crude oil was reddish-brown in colour, and had the characteristic odour of those belonging to the cineol-pinene class. It was rich in cineol, contained a small quantity of pinene, but phellandrene was absent. Crystallised eudesmol was detected at the time of distillation. Ninety-one per cent. of the oil distilled below  $183^{\circ}$  C., so that constituents of high boiling point were only present in small quantity, and the esters were also small in amount.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9246; rotation  $a_D$  —  $0.35^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4654, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.5.

On rectification 3 per cent. distilled below  $172^{\circ}$  C. (corr.). This portion contained rather a large amount of volatile aldehydes. Between  $172$ – $183^{\circ}$ , 88 per cent. distilled, and between  $183$ – $200^{\circ}$ , 4 per cent. distilled.

The large fraction had specific gravity at  $15^{\circ}$  C. = 0.9213; and rotation  $a_D$  —  $1.1^{\circ}$ .

The cineol, determined by the phosphoric acid method in the large fraction, was 64 per cent., indicating about 58 per cent. in the crude oil (O.M.).

The lævo-rotation was due to the presence of aromadrendral. The reason the large fraction shows a higher rotation to the left than does the crude oil is due to the influence of the dextro-rotatory eudesmol.

This species produces an excellent cineol-pinene oil, and it is unfortunate the yield is so low.

This sample of oil had been stored in the dark, and in October, 1919, was again analysed. Not much alteration was observed except that the oil had become a little richer in cineol, and had become inactive. 92 per cent. distilled below  $190^{\circ}$  C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9260; rotation nil; refractive index at  $20^{\circ}$  = 1.4630.

Large fraction     „     „     = 0.9160; rotation  $a_D$  —  $0.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4610.

The cineol was determined by the resorcinol method in the large fraction, and calculated for the crude oil; the result was 80 per cent. By the rapid phosphoric acid method it was 66 per cent. when calculated for the crude oil.



## 97. *Eucalyptus oleosa*.

(F.v.M., in Neder. Kruid. Arch., iv, 127.)

**Red or Water Mallee.\***

**Systematic.**—A small tree or shrub, under 20 feet. Bark rough and persistent (F.v.M.), branches smooth. Leaves scattered, narrow-lanceolate, acuminate, varying in length from 4 to 6 inches, coriaceous; venation indistinct, or obscured, oblique veins fine, numerous, intramarginal vein slightly removed from the edge. Oil glands very numerous, but hidden, owing to the thick cuticle. Peduncles axillary or lateral, each with about six to eleven pedicellate flowers on slender stalklets, slightly longer than the calyx. Calyx turbinate, a little over 2 lines long, and 2 lines in diameter; operculum conical, acuminate, rarely obtuse, usually exceeding the calyx tube, and sometimes much longer.

**Fruit.**—Globular, truncate; rim thin, contracted at the orifice; valves acute, long and slender, well exserted; under 3 lines in diameter.

*The long slender exserted valves are a very marked feature of the fruit of this species, and make the herbarium material easy of determination.*



**Habitat.**—Queensland; Victoria; South Australia; Western Australia; south and western interior of New South Wales.

**REMARKS.**—In the field it is generally associated with *E. viridis*, R.T.B., *E. gracilis*, F.v.M., *E. dumosa*, A. Cunn., from which congeners it differs in fruits, nature of the bark, and timber. The bark of this tree is remarkably thin for a Eucalypt. It occurs chiefly as a "Mallee" in extended patches, sometimes covering miles of ground and is only occasionally found growing as a tree—when it attains a height of more than 30 feet, and a diameter up to 18 inches. The larger stems are generally hollow, and the timber pink, or reddish in colour, close-grained, hard, and interlocked.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nyngan, N.S.W., in November, 1899. The yield of oil was 1.1 per cent. The crude oil was reddish-brown in colour, and had an odour resembling those of the cineol-pinene class. It was rich in cineol, contained pinene, but phellandrene was absent. Aromadendral was present, and it was to this constituent that the lævo-rotation of the crude oil, and the higher boiling fraction was due. After some time the crude oil deposited a powdery substance in considerable quantity. The high-boiling portion contained some sesquiterpene, but the amount of esters was small.

The crude oil had specific gravity at 15° C. = 0.925; rotation  $\alpha_D$  — 1.5°; refractive index at 20° = 1.4689, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.9.

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\* The term "Mallee" is applied in Australia to those Eucalypts which differ in their mode of growth from other species, by sending out a number of small stems from an expanded root-stock, as shown in the plate.

On rectification, only a small amount came over below  $170^{\circ}$  C. (corr.). Between  $170$ – $183^{\circ}$ , 78 per cent. distilled; between  $183$ – $250^{\circ}$ , 10 per cent. came over, and between  $250$ – $260^{\circ}$ , 3 per cent. distilled. These fractions gave the following results:—

|                 |                            |   |        |                |                      |
|-----------------|----------------------------|---|--------|----------------|----------------------|
| First fraction, | sp. gr. at $15^{\circ}$ C. | = | 0.919; | rotation $a_D$ | + $0.85^{\circ}$ .   |
| Second          | "                          | " | =      | 0.938;         | " — $11.3^{\circ}$ . |
| Third           | "                          | " | =      | 0.942;         | " not taken.         |

PLATE LII.



EUCALYPTUS OLEOSA, F.v.M.

"RED" OR "WATER MALLÉE."

The figures for the optical rotations indicate the presence of aromadendral. The high specific gravity of the crude oil is partly due to the comparatively large amount of the sesquiterpene.

The cineol was determined by the phosphoric acid method in the first fraction; the result was 61 per cent., or about 52 per cent. in the crude oil (O.M.).

This sample of oil had been stored in the dark, and in September, 1919, was again analysed. 84 per cent. distilled below  $190^{\circ}$  C. The specific gravity had increased a little, while the left rotation of the original oil had diminished. It was a little richer in cineol and had formed a deposit. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9400; rotation nil; refractive index at  $20^{\circ}$  = 1.4690.

Rectified portion " = 0.9240; rotation  $a_D$  +  $1^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4638.

The cineol was determined by the resorcinol method in the rectified portion, and calculated for the crude oil; the result was 71 per cent. By the rapid phosphoric acid method it was 62 per cent., when calculated for the crude oil.



"MALLEES."

(1) *EUCALYPTUS OLEOSA*, F.v.M. (2) *EUCALYPTUS DUMOSA*, A. CUNN.

R. T. Baker, del. ad nat.





## 98. *Eucalyptus dumosa*.

(A. Cunn., Schau. in Walp. Rep., ii, 925.)

**Bull Mallee.**

**Systematic.**—Found only in the dry interior of the Continent, and rarely attains tree form. The bark is white and smooth. Leaves lanceolate, under 4 inches long, shortly acuminate, coriaceous, shining, of a dull yellow colour; venation fairly prominent, lateral veins distinct, intramarginal one removed from the edge. Oil glands quite obscured. Peduncles axillary, short, bearing a few flowers on short pedicels. Calyx tube cylindrical, occasionally angular, almost 3 lines long; operculum short, conical.

**Fruit.**—Shortly pedicellate or sessile, obovoid or oblong, slightly ribbed; rim narrow, sunken; valves slightly exserted; about 3 lines long.

*The fruits might be mistaken for a small variety of E. costata.*



**Habitat.**—Southern interior of New South Wales; South Australia; Victoria. The Kangaroo Island species has a coarser fruit.

**REMARKS.**—This species was considered by Baron von Mueller as a variety of *E. incrassata*, Labill., but Bentham records them as specifically distinct in the *Flora Australiensis*, and judging from the material in the National Herbarium, Melbourne, we think Bentham is correct in his classification. Labillardiere's species has a larger fruit than A. Cunningham's *E. dumosa*. The former species occurs so far west from this State that it was found impracticable to procure either leaves for distillation or specimens of timber. The fruit of *E. dumosa* often has the facies of *E. oleosa*, when the valves are exserted.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Coolabah, N.S.W., in October, 1900. The yield of oil was 1 per cent. The crude oil was amber coloured, and had an odour resembling those belonging to the cineol-pinene class, and a secondary one indicating the aldehyde aromadendral. The oil was not very rich in cineol; it contained pinene, but phellandrene was absent. Aromadendral was probably present, although the dextro-rotation of the higher boiling portion suggests the presence of the liquid form of eudesmol.

The crude oil had specific gravity at 15° C. = 0.9151; rotation  $\alpha_D + 5.8^\circ$ ; refractive index at 20° = 1.4703, and was soluble in  $1\frac{3}{4}$  volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 2.93.

On rectification the usual amount of volatile aldehydes came over below 163° C. (corr.). Between 163–183°, 86 per cent. distilled; (24 per cent. below 171°); between 183–237°, 8 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9127; rotation  $\alpha_D + 7.8^\circ$ .

Second " " " " = 0.9405; " " " " + 9.1°.

The cineol, determined by the phosphoric acid in the large fraction, was 50 per cent., indicating about 44 per cent. in the crude oil (O.M.).

Material for distillation was also obtained from Gunbar, N.S.W. in December, 1900. The yield of oil was 0.98 per cent. In appearance, odour, constituents, &c., this oil differed but little from the above sample, with the exception that it was less rich in cineol and contained more terpenes, and perhaps more aromadendral. The specific gravity of the crude oil = 0.9016, and optical rotation  $\alpha_D + 2.2^\circ$ . The cineol in the crude oil, determined by the phosphoric acid method, was 33 per cent. (O.M.).

PLATE LIII.



Photo.]

[R. H. Cambage.

**EUCALYPTUS DUMOSA, A. CUNN.**

'WHITE' OR 'BULL MALLEE.'

In June, 1911, leaves and terminal branchlets for distillation were collected at the Kingscote end of Kangaroo Island, South Australia, where it is known as "Red Mallee." The leaves of this species were somewhat thick, and after steam distillation had become quite red in colour, particularly the young shoots at the end of the branchlets. This peculiar red colour of the steam-distilled leaves, was also observed with those of *E. leucoxylon*, but not with the leaves of the "White Mallee," or of any other species from Kangaroo Island.

The yield of oil was 0.96 per cent. The crude oil was reddish in colour, and in odour resembled the oils of the pinene-cineol group. Cineol was present in fair quantity, but phellandrene was absent. The low-boiling terpene was dextro-rotatory pinene, and the high-boiling fraction consisted principally of the sesquiterpene. A greater quantity of dextro-rotatory pinene was present in this oil than in those of the New South Wales samples.

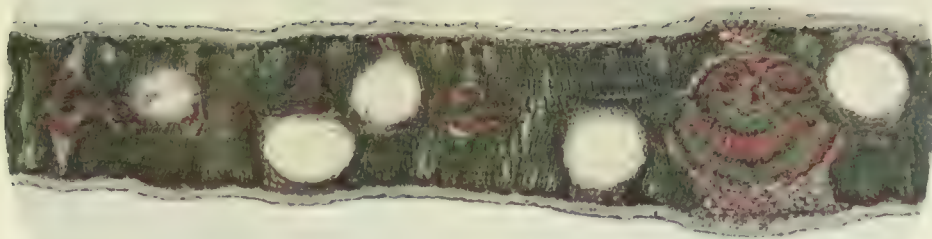
The crude oil had specific gravity at  $15^\circ\text{C.} = 0.9041$ ; rotation  $\alpha_D + 16.4^\circ$ ; refractive index at  $20^\circ = 1.4667$ , and required 1 volume 80 per cent. alcohol to form a clear solution. The saponification number for the esters and free acid was 3.7.





EUCALYPTUS POLYBRACTEA, R.T.B.  
BLUE MALLEE.





The transverse section near the mid-rib shows a very uniformly constructed texture almost entirely composed of small parenchymatous cells (palisade) typical of the "Mallees." The cuticle is slightly more strongly developed in the upper surface, stomata isogenous. The yield of oil is high and consequently oil glands are numerous. x 55.

EUCALYPTUS POLYBRACTEA R.T.B.

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On rectification a few drops of acid water with some aldehydes came over below  $163^{\circ}\text{C}$ . (corr.). Between  $163\text{--}167^{\circ}$ , 32 per cent. distilled; between  $167\text{--}198^{\circ}$ , 53 per cent. came over; the temperature then rose to  $245^{\circ}$ , and between  $245\text{--}272^{\circ}$ , 10 per cent. distilled. These fractions gave the following results:—

|                 |                                   |           |                                 |                                            |
|-----------------|-----------------------------------|-----------|---------------------------------|--------------------------------------------|
| First fraction, | sp. gr. at $15^{\circ}\text{C}$ . | = 0.8854; | rotation $a_D + 24.5^{\circ}$ ; | refractive index at $20^{\circ}$ = 1.4629. |
| Second          | „ „ „                             | = 0.9022; | rotation $a_D + 14.1^{\circ}$ ; | refractive index at $20^{\circ}$ = 1.4625. |
| Third           | „ „ „                             | = 0.9289; | rotation not taken;             | refractive index at $20^{\circ}$ = 1.4920. |

The cineol was determined by the resorcinol method in the portion distilling below  $198^{\circ}$ ; when calculated for the crude oil the result was 42 per cent.

The oil belongs to the pinene-cineol class, and does not contain constituents of a special character. The species is thus of little value as an oil-producing tree, particularly as others are available from which a superior oil can be obtained.

The chemical resemblance between this species and *E. leucoxydon*, shown by the formation of the red colouration of the leaves when steam-distilled, is further exemplified with their oils, which are in close chemical agreement.

## 99. *Eucalyptus polybractea*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 692.)

### Blue Mallee.

**Systematic.**—A glaucous shrub, with quadrangular branchlets. Leaves lanceolate (those on the early shoots lanceolate to oblanceolate), erect, rarely falcate, not oblique, narrow, under 6 lines broad, mostly 3 inches long, acuminate, often with a recurved point, not shining; mid-rib raised on the under side, giving the leaf a strong resemblance to that of an *Olea*, intramarginal vein removed from the edge, lateral veins oblique, spreading, finely marked, only occasionally distinctly pronounced; petiole about 3 lines long. Peduncles axillary, short, 2 to 3 lines long, angled, with from eight to twelve flowers. Buds angular, 1 to  $1\frac{1}{2}$  lines long, glaucous in the early stages of development, surrounded by numerous acuminate glabrous, ribbed, whitish bracts. Calyx conical, tapering into an exceedingly short pedicel; operculum obtuse, or only very slightly acuminate, hemispherical.

**Fruit.**—Hemispherical to pear-shaped, glaucous; rim thin, slightly contracted; valves deeply set, not exserted; 2 lines in diameter.



*The fruits of E. Woollsiana and E. viridis are uncommonly like those of this species, so care is required in separating them.*

**Habitat.**—Wyalong and large areas west of that district, New South Wales; also Bendigo district, north of Victoria,

**REMARKS.**—This Eucalypt is one of the "Mallees" occurring between the Lachlan and Murrumbidgee Rivers, New South Wales, where it is known as "Blue Mallee," to distinguish it from its congeners. The dried herbarium material requires care in separating from that of *E. viridis*, R.T.B., and *E. Woollsiana*, R.T.B. The type specimen of *E. fruticetorum* is lost according to Mr. J. H. Maiden (Crit. Rev. Gen. Euc., Vol. II, p. 40-41). His statement (Proc. Roy. Soc. Vict., Vol. 26, p. 299)—"Having found Mueller's *fruticetorum* (not type, for that is lost) but the next best thing a specimen certified by the describer," can have but little specific botanical weight. The specimen we have seen in the Melbourne Herbarium, under that name is a recent piece of *E. polybractea*. According to Mr. J. H. Maiden, the original description of *E. fruticetorum* was in manuscript, and was published in type in Mueller's *Fragmenta*, ii., 57. One has only to compare this description and the localities given, with those of *E. polybractea* to realise that the two are quite distinct.

**ESSENTIAL OIL.**—It was in December, 1900, that we first obtained, from Wyalong, New South Wales, material for distillation of this "Mallee." At that time, practically nothing was known in this State of its possibilities as an

PLATE LVI.



*E. POLYBRACTEA*, R.T.B.  
BLUE MALLEE.

oil producing species, and it was even scientifically undescribed. The material we received was from old trees, no abnormal leaves being present, so that a minimum yield of oil was obtained at that time, and also an excess of aromadendral. During later years large quantities of oil have been distilled from this Eucalypt in the Wyalong district, so that the knowledge as to its capabilities for oil production is now extensive; the constitution and value of the oil are also well known. *E. polybractea* is a well defined species, and has long ago been stabilised, consequently the oil is constant in composition, and of a very definite character.

We give here the results of the first investigation on the oil of this species, as published in the first edition of this work, as it may well be of historic interest, *Eucalyptus polybractea* being one of the most important of all the species for the production of a rich cineol oil.

The leaves and branchlets were collected as would be done for commercial purposes. The yield of oil was 1.35 per cent. The crude oil was but little coloured, being of a lemon tint. The odour was that of the better class of cineol-pinene Eucalyptus oils generally, and it gave a secondary one indicating aromadendral. The

amount of volatile aldehydes, esters and free acid, was almost at a minimum. Pinene was present, but phellandrene was absent. The oil was very rich in cineol, and contained aromadendral, to the presence of which the lævo-rotation of the oil was due; this is also shown by the left rotation of the crude oil being greater than that of the rectified portion.



The crude oil had specific gravity at 15° C. = 0.9143; rotation  $\alpha_D$  — 1.95°; refractive index at 20° = 1.4679, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 4.5.

On rectification, 1 per cent. distilled below 167° C. (corr.). Between 167–183°, 89 per cent. distilled; between 183–224°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9109; rotation  $\alpha_D$  — 1.2°.

Second " " " = 0.9236; " " not taken.

The cineol, determined by the phosphoric acid method in the first fraction and calculated for the crude oil, was 57 per cent. (O.M.).

The oil of this species has a strong resemblance to that obtained from *E. cneorifolia* of South Australia, although containing less aromadendral, and more cineol. (See also under "Quantitative determination of cineol.")

It was soon found that the new growth, or "suckers," as they are known vernacularly, contained a larger amount of oil than occurs in the old leaves, so that it was to the advantage of the distiller to obtain as much of this young material as possible. The oil from the young growth also contains a less amount of aromadendral, and other high-boiling constituents, than does that from old leaves, and the cineol is more pronounced in consequence. It is customary also for the distiller not to treat the leaves for too long a time, as practically all the cineol comes over during the first two hours, much of the high-boiling constituents remaining in the leaf, consequently most commercial samples of the oil of this species, as now supplied, are slightly dextro-rotatory, and if the leaves are not distilled beyond 1½ to 2 hours, the rotation may even exceed 1 degree to the right. This peculiarity is entirely due to the absence of sufficient aromadendral in the oil to overcome the slight dextro-rotation of the pinene.

A table giving the constants for numerous authentic samples of the oil of this species, commercially distilled, will be found later in the articles published in this work, where the question of constancy in the oil product, as well as methods for securing fresh growth of material are dealt with.

The rectified oil of *E. polybractea* is one of the best for the preparation of pure cineol by the freezing method. We have made numerous analyses on the oil of this species at various times, and have always found these to be in agreement.

In the following table are recorded the results we have obtained with commercial samples of the oil of this species, during the years 1918 and 1919, all of which were distilled at Wyalong:—

| Date               | Sp. gr.<br>at 15° C | Optical rota-<br>tion $\alpha_D$ . | Ref. index at<br>20° C. | Solubility in 70<br>per cent. alcohol. | Cineol,<br>per cent. |
|--------------------|---------------------|------------------------------------|-------------------------|----------------------------------------|----------------------|
| Jan., 1918 ... ..  | 0.9250              | +0.8°                              | 1.4599                  | 1 vol.                                 | 81                   |
| April, 1918 ... .. | 0.9222              | +1.1°                              | 1.4596                  | 1 vol.                                 | 83                   |
| April, 1918 ... .. | 0.9275              | +0.8°                              | 1.4594                  | 1 vol.                                 | 82                   |
| May, 1918 ... ..   | 0.9238              | +1.1°                              | 1.4597                  | 1 vol.                                 | 82                   |
| Sept., 1918 ... .. | 0.9229              | +0.5°                              | 1.4609                  | 1.1 vol.                               | 81                   |
| Oct., 1918 ... ..  | 0.9274              | +0.8°                              | 1.4616                  | 1.1 vol.                               | 79                   |
| Nov., 1918 ... ..  | 0.9264              | +0.6°                              | 1.4600                  | 1.1 vol.                               | 80                   |
| Nov., 1918 ... ..  | 0.9239              | +1.8°                              | 1.4601                  | 1.1 vol.                               | 81                   |
| June, 1919 ... ..  | 0.9251              | +1.3°                              | 1.4607                  | 1.1 vol.                               | 80                   |
| Sept., 1919 ... .. | 0.9273              | +0°                                | 1.4596                  | 1.1 vol.                               | 83                   |

The yield of oil obtained commercially varies according to the time of year, and is also influenced by the amount of young leaf present. Statements made by the distillers vary much, these ranging from 12 lbs. of oil per 400 gallon tank, to 30 lbs. per tank. The yield is also largely governed by the way the leaf is cut, if cut too coarsely the loss is in two directions; (a) deficiency of leaf, and (b) the springy nature of the coarser stems preventing sufficient loading in the tank. In a letter we received from a correspondent who gave his results for three months (November, December, and January), this is brought out clearly. Taking the young leaf cut finely, the average yield during that period was 65 lbs. of oil per ton of material; but for old leaves, coarsely cut, the average yield was only 32 lbs. per ton. This works out at 2.9 per cent. for young leaf, and 1.43 per cent. for old leaf, practically the same as we obtained in the first investigation. Another distiller informs us that his digesters hold 15 cwt. of material, and that he obtains as an average 30 to 32 pounds of oil, or 1.8 to 1.9 per cent., but that at times he has obtained up to 40 lbs.

It appears, therefore, that the yield of oil from old leaf of *E. polybractea*, cut fairly, will be about 1.5 per cent., and from the young material about 2.5 per cent.

PLATE LVII.



E. POLYBRACTEA, R.T.B.

"BLUE MALLEE."

In this Plate the dense growth of this Mallee is shown. It will be seen that there is an absence of tall trees over the district.

## 100. *Eucalyptus cneorifolia*.

(DC., in Prod., iii, p. 220.)

**Narrow-leaved Mallee.**

**Systematic.**—A shrub or small tree. Leaves from narrow-linear to oblong-lanceolate, straight or rarely falcate, mostly under 4 inches long, thick, with fine diverging veins scarcely ever visible. Peduncles short, terete or scarcely angular, each with a head of four to eight flowers, closely sessile or obscurely pedicellate. Calyx 2 to  $2\frac{1}{2}$  lines long, rather thick, but not angular; operculum hemispherical, much shorter than the calyx tube.

**Fruit.**—Pear-shaped or nearly globular, contracted at the orifice; rim rather thick, flat or slightly convex; the capsule more or less sunk; but the valves often slightly protruding, about 3 lines in diameter.

*The resemblance in these fruits is nearest to E. Wilkinsoniana, E. Banksia, E. Moorei, and occasionally E. eugenioides.*



**Habitat.**—Kangaroo Island, South Australia.



PLATE LVIII.



*C. Toms, del.*

**EUCALYPTUS CNEORIFOLIA, DC.**  
NARROW LEAF MALLEE.

LINE OF  
CALIFORNIA





**REMARKS.**—Bentham's (*loc. cit.*) classification is followed in regard to this species. Mueller synonymises De Candolle's species under *E. stricta*, but material of these two species show them to be quite distinct. De Candolle's and Bentham's descriptions very aptly describe the Kangaroo Island Eucalypt; the tree, however, does not appear to occur on the mainland of South Australia.

**ESSENTIAL OIL.**—Material consisting of the leaves and terminal branchlets for distillation were collected at the Kingscote end of Kangaroo Island, in the month of June, 1911. This species is the principal one on the island from which Eucalyptus oil is distilled for pharmaceutical purposes. It is one of the "Mallees," or shrubby Eucalypts, and is a very common species on Kangaroo Island, where it is known as "Narrow-leaf."

The species known there as "Peppermint" (*E. odorata*) seems to be closely related, chemically, to *E. cneorifolia*, and the oils distilled from these two trees show great resemblances. The principal constituent is cineol, and pinene is only present in comparatively small amount. The high-boiling aldehyde, aromadendral, is a characteristic constituent in this oil, even more so than in that of the "Peppermint." The rectified oil of *E. cneorifolia* was slightly yellow in tint, as is usual with the oils of this group. This colour is due apparently to the influence of the particular phenol present. The product of this species is one of the most pronounced cineol-bearing oils in Kangaroo Island, but requires rectification, so that the aromadendral, sesquiterpene, and other high-boiling constituents may be removed as much as possible.

The yield of oil was 1.8 per cent., but this may be taken as the minimum yield, the material being collected in midwinter, and from old trees. The crude oil was orange-brown in tint, and had an odour similar to the cineol-pinene oils of this group, with a secondary one of aromadendral. Volatile aldehydes were present, but phellandrene was absent.

The crude oil had specific gravity at 15° C. = 0.9229; rotation  $a_D$  — 3.3°; refractive index at 20° = 1.4664, and was soluble in 1¼ volumes 70 per cent. alcohol. The lævo-rotation of this oil is largely due to the aromadendral.

On rectification, a few drops of acid water with some aldehydes came over below 174° C. (corr.). Between 174–185°, 81 per cent. distilled; between 185–220°, 9 per cent. came over, and between 220–237°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9166; rotation  $a_D$  — 1.1°; refractive index at 20° = 1.4632.

Second     ,,           ,,           ,,     = 0.9172; rotation  $a_D$  — 4.1°; refractive index at 20° = 1.4678.

Third       ,,           ,,           ,,     = 0.9291; rotation  $a_D$  — 16.2°; refractive index at 20° = 1.4866.

The high lævo-rotation of the third fraction was due to the aromadendral. The cineol was determined by the resorcinol method in the fractionated oil; when calculated for the crude oil the result was 87 per cent. By the phosphoric acid method it was 62 per cent. The saponification number for the esters and free acid was 7.4. (See further analysis under "Quantitative determination of cineol.")

In the year 1901, Messrs. Faulding & Co., of Adelaide, South Australia, forwarded to us a quantity of the oil of this species which had been distilled in Kangaroo Island. The results of the investigation on that sample were published in the first edition of this work. The oil resembled in every way the product we distilled from leaves forwarded to us, the analysis of which is recorded above.

The crude oil had specific gravity at 15° C. = 0.9287; rotation  $a_D$  — 5.4°; refractive index at 20° = 1.4690, and was soluble in 1¼ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 16.

Between 174–188° C. (corr.), 80 per cent. distilled; between 188–210°, 7 per cent., and between 210–232°, 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9211; rotation  $a_D$  — 2.95°.

Second „ „ „ = 0.9274; „ „  $a_D$  — 5.34°.

Third „ „ „ = 0.9439; „ „ not taken.

The cineol in the crude oil, determined by the phosphoric acid method in the first fraction, was 54 per cent. (O.M.). The lævo-rotation of the oil was due to the aromadendral.

## 101. *Eucalyptus odorata*.

(Behr., in Linnæa, XX, 657.)

**Box-tree or Peppermint.**

**Systematic.**—A small tree, or “Mallee,” bark “Box”-like. Abnormal leaves linear to broadly lanceolate, dull, often glaucous or bluish green. Normal leaves narrow lanceolate, rigid, of a dull green or somewhat shining; intra-marginal vein somewhat removed from the edge; venation oblique, about 30° from the mid-rib. Peduncles mostly axillary,  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long, bearing about seven almost sessile flowers. Buds clavate; calyx tube tapering gradually to peduncle and about twice as long as the conical obtuse operculum.

**Fruit.**—Cylindrical to sometimes pyriform, almost sessile, more or less angular; rim counter-sunk; valves scarcely or not exerted; about 4 lines long and up to 3 lines broad.



*It is very difficult at times to differentiate these fruits from those of E. dumosa or perhaps E. paniculata*

**Habitat.**—New South Wales; Victoria; and South Australia.

**REMARKS.**—Behr's species is acknowledged in Bentham's “Flora Australiensis” and Mueller's “Eucalyptographia,” and later by Maiden in his “Critical Revision of the Eucalypts,” vol. ii, Part I, p. 26, as well as in the Trans. Roy. Soc. S.A., 1903, where he goes fully into the synonymy of the species.

With most of this latter synonymy we are not in accord, especially in placing *E. Lansdowniana* under *E. odorata*. Brown, in his “Florest Flora of South Australia,” figures both species, and if any reliance can be placed in delineation, greater differences could not be illustrated. Brown's figure is what we regard as *E. Woolfsiana*.

**ESSENTIAL OIL.**—Material for distillation was collected at the Kingscote end of Kangaroo Island in July, 1911. This species is considered by Eucalyptus oil distillers of Kangaroo Island to be of equal value with *E. cneorifolia* for oil production.

The origin of the name “Peppermint” for this species could not be traced, and it seems to be altogether a misnomer, as the ketone of peppermint odour (piperitone) appears to be absent in this oil, the characteristic high-boiling constituent being aromadendral. The name “Peppermint” is also given to Eucalyptus species in New South Wales, the oils of which do not contain piperitone, nor do their oils have a peppermint odour. The oils of the true “Peppermint” Eucalyptus species usually contain the terpene phellandrene, piperitone being also a characteristic constituent.



PLATE LIX.



Box Tree,  
Peppermint.

R. T. Baker, del.

**EUCALYPTUS ODORATA, BEHR.**  
BOX TREE, PEPPERMINT.



The yield of oil was 1.87 per cent., but as the material was collected in the winter this may be taken as the minimum yield. The crude oil was orange-brown in tint, indicating but a trace of phenol, and had an odour similar to those belonging to the cineol-pinene group, with a secondary one indicating aromadendral. Volatile aldehydes were pronounced. The oil was rich in cineol, and phellandrene was absent.

The crude oil had specific gravity at 15° C. = 0.9193; rotation  $a_D$  — 1.1°; refractive index at 20° = 1.4639, and was soluble in  $1\frac{1}{4}$  volumes 70 per cent. alcohol. The lævo-rotation shown by this oil is due to the aromadendral. The saponification number for the esters and free acid was 8.5.

On rectification a few drops of acid water with some aldehydes came over below 173° C. (corr.), showing the comparative absence of the low-boiling terpenes. Between 173–185°, 82 per cent. distilled; between 185–215°, 8 per cent. came over, and between 215–230°, 4 per cent. distilled. These fractions gave the following results:—

|                             |                                                                                      |
|-----------------------------|--------------------------------------------------------------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.9153; rotation $a_D$ — 0.1°; refractive index at 20° = 1.4619. |
| Second     ,,     ,,     ,, | = 0.9161; rotation $a_D$ — 0.7°; refractive index at 20° = 1.4639.                   |
| Third     ,,     ,,     ,,  | = 0.9219; rotation $a_D$ — 11.7°; refractive index at 20° = 1.4794.                  |

The high lævo-rotation of the third fraction is due to the aromadendral. The cineol was determined by the resorcinol method in the oil distilling below 185°; when calculated for the crude oil, the result was 86 per cent. By the phosphoric acid method it was 63 per cent. (See also further analysis under "Quantitative Determination of Cineol.")

The rectified oil was slightly yellow in tint, due to the particular phenol present.

There is a strong resemblance between the oil of this Eucalypt and that of "Narrow Leaf," *E. cneorifolia*, and for commercial purposes no marked differences could be detected between the products of the two species.

The results obtained with the oil of this Eucalypt were published by us in the Trans. Roy. Soc., South Australia, 1916.



## GROUP IV.

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CLASS (b).

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In this Group are placed the following EUCALYPTS yielding an oil containing over 40 per cent. of cineol, but in which phellandrene is making its appearance, thus approaching the more pronounced phellandrene-bearing oils.

- 102. *Eucalyptus melliodora.*
  - 103. *E. ovalifolia* var. *lanceolata.*
  - 104. *E. Consideniana.*
  - 105. *E. Risdoni.*
  - 106. *E. linearis.*
-

## 102. *Eucalyptus melliodora*.

(A. Cunn., Herb.)

Yellow Box.

**Systematic.**—Generally a fair-sized tree. Bark persistent, smooth, and buff-coloured, or sometimes rugged towards the base; of a rich yellow colour on the inner side. Abnormal leaves oval, or ovate-lanceolate, thin, variable in size; venation faintly marked, lateral veins parallel, distant, intramarginal vein much removed from the edge. Normal leaves lanceolate to ovate-lanceolate, under 6 inches long; venation not well marked except the intramarginal vein, which is removed from the edge, and is so distinct at the base as to give a trinerved appearance to the leaf; dry a pale yellow colour. Peduncles short, axillary, slender, with about six flowers in the umbel. Calyx scarcely 2 lines in diameter, conical, on a pedicel of about 2 lines; operculum short, hemispherical, obtuse.

**Fruit.**—Mostly hemispherical, but occasionally pyriform; rim thin, sometimes with a constriction immediately below it; valves not exerted; under 3 lines in diameter.



*The fruits, with the strongly-marked rim which sometimes becomes detached, much resemble E. Blackburniana and E. Laseroni, whilst the other form approaches in shape E. odorata or E. paniculata.*

**Habitat.**—Tableland from Queensland into Victoria.

**REMARKS.**—The common name "Yellow Box" appears to be uniformly applied to this tree, both in New South Wales and Victoria. It derives its vernacular name from (1) the yellowish appearance of the inner surface of the bark; (2) the timber, which is hard, close, interlocked, and pale yellow coloured, and very durable. It is highly prized as fuel. It is a very distinct species, and no better example could be quoted of specific characters of the Genus than is illustrated in this widely-distributed Eucalyptus, for its botanical characters show little variation, whatever the environment may be.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Rylstone, N.S.W., in April, 1898. The yield of oil was 0.87 per cent. The crude oil was red in colour, and had an odour resembling the cineol-pinene oils generally. The presence of volatile aldehydes was also shown. The oil was rich in cineol, and when rectified was almost colourless, and, as a cineol-pinene oil, of very fair quality, although the specific gravity was remarkably low, and in this did not reach the standard for specific gravity (0.91) as laid down by the British Pharmacopœia. This low specific gravity of the oil from this species is perhaps partly due to the time of the year when distilled, and also to the presence of a small quantity of phellandrene present in the oil. This species is probably one of the links that connect the phellandrene-bearing oils with those belonging to the more pronounced cineol-pinene groups. That this tendency is in the direction of the phellandrene group of Eucalyptus oils, is indicated by the removal of the marginal vein far from the edge of the leaves, a character which shows affinity with those species giving phellandrene-bearing oils. The variation in specific gravity of Eucalyptus oils is largely governed by the amount of high-boiling constituents present, and for this reason the specific gravity of the

oil of any one species varies slightly at different times of the year. Pinene was present in the oil of this species, and from the results, as well as on theoretical grounds, it would appear that the oil consisted very largely of cineol and pinene, with a small quantity of phellandrene.

The crude oil had specific gravity at 15° C. = 0.9046; rotation  $a_D + 6.5^\circ$ ; refractive index at 20° = 1.4649, and was soluble in 6 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 7.2.

On rectification 2 per cent. distilled below 162° C. (corr.). Between 162–183°, 83 per cent. distilled; between 183–255°, 8 per cent. came over, and between 255–270°, 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9012; rotation  $a_D + 7.2^\circ$ .

Second „ „ „ = 0.9201; „ + 1.23°.

Third „ „ „ = 0.9331; „ not taken.

The cineol, determined by the phosphoric acid method in the large fraction, was 60 per cent. (O.M.), indicating about 52 per cent in the original oil.

The above results being unusual for an oil so rich in cineol, a second distillation was made, but in this instance the rectification was carried to 190° C. The large fraction represented 88 per cent. of the original oil. It had a specific gravity of 0.9019 at 15° C., and optical rotation  $a_D + 7.1^\circ$ . The cineol determined by the phosphoric acid method was 59 per cent. (O.M.), a mean of closely agreeing results.

Material of this species was also obtained from Condobolin, N.S.W., in March, 1901. It had specific gravity = 0.9042, contained similar constituents to the above, and was soluble in 6 volumes 70 per cent. alcohol.

Material of this species for distillation was also obtained from Barber's Creek, N.S.W., in June, 1898. This is the cold time of the year in Australia, and consequently the oil contained less pinene and had a higher specific gravity. The yield of oil was also less. The ester content was somewhat high in this sample, and phellandrene could not be detected, indicating a diminution of that constituent at this time of the year. The specific gravity of the crude oil was 0.9321; and optical rotation  $a_D + 5.0^\circ$ . The fraction (81 per cent. distilling below 183° C.) had specific gravity = 0.9143; and optical rotation  $a_D + 6.6^\circ$ . The saponification number for the esters and free acid was 21.96. The cineol, determined by the phosphoric acid method in the rectified oil, was 60 per cent. (O.M.). The crude oil formed a clear solution with 1½ volumes 70 per cent. alcohol.

### 103. *Eucalyptus ovalifolia*, R.T.B. var. *lanceolata*.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, 1st Ed., 1902, p. 124.)

**Systematic.**—A typical forest tree, with a smooth bark. Leaves lanceolate, 4 to 6 inches long or more, rarely above 1 inch broad, thin, almost membranous, not shining, dull green colour on both sides, occasionally drying brownish; petiole slender, over 1 inch in length; venation finely defined, lateral



veins oblique, spreading, the distant ones being more distinct, intramarginal vein removed from the edge. Inflorescence in axillary or terminal panicles; pedicels about 3 lines long, slender. Calyx conical, 2 lines in diameter, operculum hemispherical, shortly acuminate.

**Fruit.**—Conical; rim thin, contracted, sometimes lacerated, valves deeply inserted; about 2 lines or slightly more in diameter.

*In general shape they resemble E. conica, E. Fletcheri and E. polyanthemus, but are larger.*



**Habitat.**—Camboon, Rylstone, Hargraves, Wellington, New South Wales.

**REMARKS.**—This variety is placed with *E. ovalifolia* on account of a resemblance in the morphological characters of the fruits (partly) and buds, as well as the bark and nature of the timber. The trees of the two (the type and variety) are quite different in the field, and timber-getters and settlers never confound them. The constant shape of the leaves and the pyriform fruits and chemical constituents are the principal features of difference between it and the type.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Camboon, N.S.W., in March, 1901. The yield of oil was 0.58 per cent. The crude oil was of a light amber colour, and had an odour resembling those belonging to the cineol-pinene class of Eucalyptus oils. Pinene and phellandrene were both present, and also a good quantity of cineol. It is unusual for an oil containing so much phellandrene to be so rich in cineol, particularly as the terpene in the richer cineol oils is generally pinene. The higher boiling portion contained the sesquiterpene. The lævo-rotation of the oil was largely due to the presence of phellandrene; the amount of esters was not large.

The crude oil had specific gravity at 15° C. = 0.9083; rotation  $a_D$  — 4.26°; refractive index at 20° = 1.4654, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.8.

On rectification 1 per cent. distilled below 157° C. (corr.). Between 157–188°, 92 per cent. distilled, and between 188–250°, 3 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.9068; rotation  $a_D$  — 5.9°.

Second " " " " = 0.9336; " not taken.

The cineol, determined by the phosphoric acid method in the large fraction, was 48 per cent. (O.M.), indicating about 45 per cent. in the crude oil.

The oil from this variety differs from that of *E. ovalifolia* itself in containing more pinene and much more cineol.

This sample had been stored in the dark, and in September, 1919, was again analysed. The lævo-rotation had diminished, and the cineol increased a little in amount. 90 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9148; rotation  $a_D$  — 1.4°; refractive index at 20° = 1.4658.

Rectified portion " " " " = 0.9099; rotation  $a_D$  — 2.2°; refractive index at 20° = 1.4621.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 67 per cent. By the rapid phosphoric acid method, it was 56 per cent. when calculated for the crude oil.

## 104. *Eucalyptus Consideniana*.

(J.H.M., Proc. Linn. Soc., N.S.W., 1904, p. 475.)

**Systematic.**—A tree of medium height, with a peppermint bark. Abnormal leaves narrow, ovate lanceolate, petiolate, alternate, thin, margin slightly crenulate, usually under 3 inches long. Branchlets angular. Normal leaves broad lanceolate, oblique to falcate, acuminate, up to 10 inches in length, older leaves rather thick and shining; venation not prominent, except in young leaves, intramarginal vein distant from the edge, lateral veins spreading, oblique. Peduncles axillary or lateral, 3 to 6 lines long with umbels of six to twelve flowers. Buds clavate; calyx tube narrow, conoidal, tapering to a slender pedicel; operculum hemispherical, sometimes shortly pointed.

**Fruit.**—Pyriform or inclined to conical, shortly pedicellate, only slightly contracted at the orifice; rim broad, flat or slightly domed, shining, reddish in colour; valves scarcely exerted; 5 lines long and  $3\frac{1}{2}$  lines in diameter.



*These might easily be mistaken for E. campanulata, which they somewhat resemble. The next in similarity are E. virgata and E. Sieberiana.*

**Habitat.**—Coastal and Coast Range districts of New South Wales; and Gippsland, Victoria.

**REMARKS.**—Only in herbarium material is it possible to confound it with the species mentioned under the fruits. The field characters, however, especially the bark (peppermint), are sufficient to distinguish it from those.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Nowra, N.S.W., in March, 1912. The yield of oil was 1.2 per cent. The crude oil was light amber in colour, and had an odour similar to that given by the cineol-phellandrene Eucalyptus oils generally, with a secondary one somewhat aromatic. The oil was fairly rich in cineol; contained some phellandrene, although this was small in amount at this time of the year; pinene was present and rather a large proportion of what appears to be the liquid form of eudesmol. This is shown by the constants for the third fraction, and also by those obtained with the higher fractions of the portion boiling above 190° C., in the first distillation. It is doubtful if piperitone was present, if so, the amount was very small. A small quantity of a solid paraffin was detected, and terpineol was also present.

The crude oil had specific gravity at 15° C. = 0.9207; rotation  $\alpha_D + 2.9^\circ$ ; refractive index at 20° = 1.4737, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.7.







crystals had apparently grown. The identity of this alcohol is thus not so completely shown as was the case with the oil of *E. Rossii*, for instance, which was changed into the crystalline form on distillation under reduced pressure. (See under that species, and also the article dealing with eudesmol.)

## 105. *Eucalyptus Risdoni*.

(Hook. f. in Hook. Journ., vi, 477, and Fl. Tasm., i, 133, t. 24.)

**Risdon or Drooping Gum.**

**Systematic.**—A small or medium-sized tree, with a smooth, deciduous bark, and glaucous foliage, inflorescence, and branchlets. Leaves very variable in size and shape, either opposite, sessile, connate, ovate, cordate, acuminate, thick, with recurved margins, about  $1\frac{1}{2}$  inch long, or alternate, ovate-lanceolate, lanceolate and sometimes measuring 6 inches long, occasionally shining; venation fairly distinct, lateral veins oblique, spreading, distant; in the lanceolate leaves the tendency is in the direction of phellandrene oil venation; intramarginal vein well removed from the edge and showing a looping arrangement. Peduncles axillary, 3 to 4 lines long, terete or angular, bearing six to nine fairly large flowers. Calyx tube pyriform, 3 lines in diameter, 5 lines long; operculum depressed, hemispherical, shortly acuminate.

**Fruit.**—Sub-globose; truncate, sometimes contracted at the orifice, or pear-shaped; rim truncate to countersunk; valves not or scarcely exerted; 4 lines in diameter.



*These fruits could not easily be confounded with any others, although those with the countersunk rim resemble E. obtusiflora.*

**Habitat.**—Southern Tasmania.

**REMARKS.**—The life history (if one may use the expression in this connection) of this *Eucalyptus* is identical with that of the mainland species *E. dives*, Schau., in that it flowers and fruits when quite a small shrub, and when all its leaves are in the opposite, sessile, and cordate form. Singularly enough, both Hook. f. and Schauer founded their species on the shrubby form only, and in the case of *E. dives* it was not till shown by this research, that the mature trees were identified. Hook. f. figures and describes (*loc. cit.*) what has since been shown to be the primary stage of growth of his species, the mature trees of which are recorded by Bentham in his "Flora Australiensis," iii, 203, as var. *elata* on material collected by Gunn. The dried material of the early and mature forms of this tree, when compared, would easily mislead one not acquainted with the trees in the field. "Mueller unites *E. Risdoni* altogether with *E. amygdalina*," but our results agree with those of J. D. Hooker and Oldfield, and in no way do we see so close an affinity between these two trees.

**ESSENTIAL OIL.**—The results obtained with the oil of *E. Risdoni* were recorded in the first edition of this work. The yield of oil then obtained was 1.35 per cent.; saponification number for ester and free acid = 27.1; cineol



W. Marshall, del.

**EUCALYPTUS RISDONI, Hook.f.**

RISDON OR DROOPING GUM.





64 per cent. in the fraction, determined by the phosphoric acid method, and 95 per cent. distilled below  $198^{\circ}\text{C}$ . It contained phellandrene, and was exceedingly rich in cineol for a phellandrene-bearing oil.

To enable the investigation to be more complete, material was obtained for distillation of the reputed *E. Risdoni* var. *elata*, from Mount Wellington, Tasmania, collected in August, 1912. The results show the oil to be in agreement with those of the ordinary form previously determined.

Material for distillation of the so-called *E. amygdalina* var. *hypericifolia*, was also obtained by Mr. L. G. Irby, near Hobart, Tasmania, in April, 1912, under the direction of Mr. Rodway. The results with this oil were practically identical with those of *E. Risdoni*, and as the botanical features were also in agreement with that species, we consider it to be *E. Risdoni*. The chief characteristics in the oil of *E. Risdoni* are that it contains over 55 per cent. of cineol when determined by the resorcinol method; a somewhat large amount of phellandrene; belongs to the "peppermint" group, as it contains some piperitone; has a somewhat high saponification number by boiling, and a low one by the cold method; gives over 90 per cent. distilling below  $195^{\circ}\text{C}$ ., and has scarcely any objectionable volatile aldehydes. Both amyl-alcohol and amyl-acetate were detected.

The crude oil of *E. Risdoni* (supposed variety *elata*) from Mount Wellington, Tasmania, was lemon-yellow in colour, and responded to all the tests and requirements recorded above. The yield of oil was 1.52 per cent. Specific gravity at  $15^{\circ}\text{C}$ . = 0.9061; rotation  $a_D$  —  $14.1^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4670, and was soluble in 3 volumes 70 per cent. alcohol. The slightly larger amount of phellandrene, and correspondingly less cineol at the time, accounts for the slight differences in rotation, gravity, and solubility, to those previously recorded.

On rectification, the usual amount of acid water and volatile aldehydes came over below  $173^{\circ}\text{C}$ . (corr.). Between  $173$ – $184^{\circ}$ , 82 per cent. distilled, and between  $184$ – $195^{\circ}$ , 11 per cent. distilled. These fractions gave results as follows:—

First fraction, sp. gr. at  $15^{\circ}\text{C}$ . = 0.8995; rotation  $a_D$  —  $16.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4647.

Second " " " = 0.9010; rotation  $a_D$  —  $9.3^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4619.

The cineol was determined by the resorcinol method, the result indicating 58 per cent. of that constituent in the crude oil. The saponification number for the esters and free acid by boiling was 21.3; and in the cold, with two hours' contact, 5.5.

The supposed variety *hypericifolia* gave a light amber-coloured oil, having a somewhat pleasant odour; the average yield was 1.24 per cent., and the oil agreed in all respects with the requirements for that of *E. Risdoni*.

The specific gravity of the crude oil at  $15^{\circ}\text{C}$ . = 0.9045; rotation  $a_D$  —  $14.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4656, and was soluble in 5 volumes 70 per cent. alcohol. The saponification number for the esters and free acid by boiling was 23.8; and in the cold, with two hours' contact, 3.9. It is thus evident that the main ester in the oil of *E. Risdoni* is not geranyl-acetate.

On rectification, only a few drops of acid water and volatile aldehydes came over below  $173^{\circ}\text{C}$ . (corr.). These aldehydes had no objectionable odour. Between  $173$ – $198^{\circ}$ , 94 per cent. distilled. This had specific gravity at  $15^{\circ}\text{C}$ . = 0.8991; rotation  $a_D$  —  $15.4^{\circ}$ , and refractive index at  $20^{\circ}$  = 1.4637. The comparative absence of high-boiling constituents is worthy of notice.

The cineol was determined by the resorcinol method in the large fraction, and calculated for the crude oil; the result was 56 per cent.

If these results are tabulated it can be seen how closely the oils agree in general characters, and, allowing for the slight increase in cineol and less phellandrene at the time of distillation, with the type *E. Risdoni* also.

|                                    | Supposed variety<br><i>elata</i> . | So called variety,<br><i>hypericifolia</i> . |
|------------------------------------|------------------------------------|----------------------------------------------|
| Yield of oil                       | 1·2 per cent.                      | 1·24 per cent.                               |
| Rotation $a_D$                     | — 14·1°                            | — 14·6°                                      |
| Specific gravity at 15° C.         | 0·9061                             | 0·9045                                       |
| Refractive index at 20° C.         | 1·4670                             | 1·4656                                       |
| Cineol by resorcinol               | 58 per cent.                       | 56 per cent.                                 |
| Saponification number, hot method  | 21·35                              | 23·8                                         |
| Saponification number, cold method | 5·5                                | 3·9                                          |
| Boiling, between 173–195°          | 93 per cent.                       | Bet. 173–198° = 94 per cent.                 |
| Solubility in alcohol              | 3 vols., 70 per cent.              | 5 vols., 70 per cent.                        |

By the rapid phosphoric acid method the cineol was 46 per cent. when calculated for the crude oil.

Material of trees growing at Strickland, Tasmania, was obtained in August, 1912. The oil distilled from the leaves of these trees showed them to be *E. Risdoni* also, and it responded to all the tests required for the oil of that species. The yield of oil was 1·5 per cent.; specific gravity at 15° C. = 0·9079; rotation  $a_D$  — 9·9°; refractive index at 20° = 1·4677; and was soluble in 5 volumes 70 per cent. alcohol. The cineol, determined by the resorcinol method, was 58 per cent. when calculated for the crude oil. The saponification number by boiling was 21·1; and in the cold, with two hours' contact, 6·6. The presence of amyl-acetate in the portion first distilling was also indicated by the pear-like odour, after the aldehydes had been removed, and this was further intensified after acetylation.

The results of this later investigation were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

## 106. *Eucalyptus linearis*.

(A. Cunn.)

White Peppermint.

**Systematic.**—A fairly tall tree with a clean, smooth, yellow or whitish bark, sometimes rough for a few feet at the base. Abnormal leaves opposite or alternate, linear, about 2 inches long and under 2 lines wide, on slender branchlets covered with tubercles. Normal leaves narrow-lanceolate, under 4 inches long and up to 3 lines wide, thick; venation scarcely visible, except mid-rib, lateral



veins oblique. Peduncles axillary, about 3 lines long, bearing umbels of five to ten flowers. Buds clavate, tapering to a short pedicel; operculum depressed, hemispherical, often umbonate.

**Fruit.**—Pyriform, contracted at the orifice or sometimes hemispherical, shortly pedicellate, more or less shining; rim red, scarcely domed, truncate, or slightly countersunk when immature; valves scarcely exerted; 2 to 3 lines long, and  $2\frac{1}{2}$  lines in diameter.



*The fruits might be described as a slightly larger form of the true E. amygdalina, and next to these, E. dives.*

**Habitat.**—Tasmania.

**REMARKS.**—One of the easiest of "Gum" trees to be identified in the field, for the specific name is a very suitable one, the leaves being more linear than obtains in most species.

Our giving the authorship of this species to A. Cunningham is challenged by J. H. Maiden (Roy. Soc. Tas., 1914, p. 26), but as we think that no new data have been brought to light, we retain it for A. Cunningham; *vide* our Paper on "Tasmanian Eucalypts," Roy. Soc. Tas., 1912.

**ESSENTIAL OIL.**—Material for distillation was obtained from The Springs, Mt. Wellington, Tasmania, in January, 1912, at the time of year when a maximum amount of oil might be expected to occur. The yield of oil was 1.8 per cent. The crude oil was reddish in colour, and had a peppermint odour, due to the piperitone present. It contained much phellandrene and a considerable amount of cineol. Pinene was practically absent, or present only in traces. The specific gravity of the crude oil at 15° C. = 0.9096; rotation  $a_D$  — 10.2°; refractive index at 20° C. = 1.4677; and was soluble in 6 volumes 70 per cent. alcohol.

On rectification, only a few drops of acid water and volatile aldehydes came over below 173° C. (corr.), at which temperature the oil commenced to distil. Between 173–188°, 82 per cent. distilled; between 188–290°, 10 per cent. distilled, the greater portion (7 per cent.) above 260°. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8987; rotation  $a_D$  — 12°; refractive index at 20° = 1.4637.

Second " " " " = 0.9501; rotation  $a_D$  + 3.2°; refractive index at 20° = 1.4887.

There was evidently a heavy, high-boiling constituent in the oil of this species, which had a right rotation, but it was not isolated; it was evidently the non-crystallised form of eudesmol. The saponification number for the esters and free acid in the crude oil was 5.8.

The cineol was determined in the first fraction by the resorcinol method; when calculated for the crude oil the result was 52 per cent. By the phosphoric acid method it was 46 per cent. in the crude oil.

Material of this species was collected at Little Swanport, Tasmania, in June, 1908. The oil distilled from this agreed in general characters and constituents with the above. The yield of oil was 1.38 per cent. Specific gravity at 15° C. = 0.9036; rotation  $a_D$  — 9.9°; refractive index at 20° = 1.4705, and was soluble in 7 volumes 70 per cent. alcohol. Below 193° C. 77 per cent. distilled. The cineol was determined in this fraction by the resorcinol method; when calculated for the crude oil the result was 51 per cent.



Material of this species was also collected at Nubeena, Tasman Peninsula, in April, 1912. The oil agreed in general characters with those from the previous consignments, only at this time of the year rather a large amount of phellandrene was present, consequently the rotation to the left was higher; the cineol was also slightly less in amount, but still exceeded 40 per cent. in the crude oil. The yield of oil was 1.1 per cent. Specific gravity at 15° C. = 0.9045; rotation  $a_D$  — 23.1°; refractive index at 20° = 1.4734, and was soluble in 8 volumes 70 per cent. alcohol. Below 193° C. 79 per cent. distilled. The cineol in this portion was determined by the resorcinol method; the result was 44 per cent. when calculated for the crude oil.

The results of this investigation were published by us in Proc. Roy. Soc., Tasmania, October, 1912.

## GROUP V.

In this Group are placed the following EUCALYPTS yielding an oil consisting largely of cineol, pinene, and aromadendral,\* but in which the cineol does not exceed 40 per cent. Phellandrene is usually absent.

- |      |                   |                                        |
|------|-------------------|----------------------------------------|
| 107. | <i>Eucalyptus</i> | <i>tereticornis.</i>                   |
| 108. | <i>E.</i>         | <i>punctata</i> (var. <i>didyma</i> ). |
| 109. | <i>E.</i>         | <i>rostrata.</i>                       |
| 110. | <i>E.</i>         | <i>propinqua.</i>                      |
| 111. | <i>E.</i>         | <i>Deanei.</i>                         |
| 112. | <i>E.</i>         | <i>Rudderi.</i>                        |
| 113. | <i>E.</i>         | <i>salubris.</i>                       |
| 114. | <i>E.</i>         | <i>occidentalis.</i>                   |
| 115. | <i>E.</i>         | <i>exserta.</i>                        |
| 116. | <i>E.</i>         | <i>marginata.</i>                      |
| 117. | <i>E.</i>         | <i>affinis.</i>                        |
| 118. | <i>E.</i>         | <i>Fletcheri.</i>                      |
| 119. | <i>E.</i>         | <i>Woolfsiana.</i>                     |
| 120. | <i>E.</i>         | <i>albans.</i>                         |
| 121. | <i>E.</i>         | <i>hemiphloia.</i>                     |
| 122. | <i>E.</i>         | <i>gracilis.</i>                       |
| 123. | <i>E.</i>         | <i>viridis.</i>                        |
| 124. | <i>E.</i>         | <i>uncinata.</i>                       |

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\*The name Aromadendral is used throughout this work in a general sense to denote the presence of one or more members of this group of characteristic aldehydes, which includes cuminaldehyde and cryptal. (See the article in this work on these aldehydes.)

## 107. *Eucalyptus tereticornis*.

(Sm., Bot. Nov. Holl. 41 (1793), and in Trans. Linn. Soc., iii, 284.)

### Forest Red Gum.

**Systematic.**—A tall tree with a smooth bark, although occasionally rough at the base. Abnormal leaves orbicular to broadly lanceolate, 4 inches in diameter and under 6 inches long, sometimes oblique; venation very pronounced on the under side, oblique, spreading, intramarginal vein removed from the edge. Normal leaves lanceolate, measuring up to 1 foot in length and over 2 inches in width; venation distinct, spreading, oblique, intramarginal vein removed from the edge. Inflorescence either on axillary peduncles or in terminal panicles. Peduncles flattened, varying in length up to 9 lines, with seven to nine flowers in the umbel. Calyx tube hemispherical, up to 2 lines in diameter, pedicel variable in length, from under 1 line to over 3 lines; operculum conical, up to 5 or 6 lines long, acute or obtuse.

**Fruit.**—Pedicellate, hemispherical; rim domed; valves well exerted, acute; 2 to 4 lines in diameter.



*An easily recognised fruit, with its prominently exerted valves. It more particularly resembles E. rostrata and E. Seeana, than any other species.*

**Habitat.**—Coastal range and districts of New South Wales; Victoria; Queensland; Papua (J.H.M.).

**REMARKS.**—The type is well defined and widely distributed in Eastern Australia, the broad abnormal leaves, and long, conical operculum being very characteristic.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, N.S.W., in June, 1898. The yield of oil was 0.5 per cent. The crude oil was of an orange-brown colour, and had a marked odour of aromadendral. Phellandrene does not appear to occur in the oil of this species, but pinene was present in small amount, cymene was also a constituent of the oil. Cineol was detected, but the amount did not exceed 10 per cent. in the first fraction. Esters occur in some quantity. Aromadendral was a pronounced constituent in the third fraction, from which it was isolated in a pure condition, and its chemical compounds prepared. The oil of this species was almost identical with that obtained from the variety *didyma* of *E. punctata*; it has little commercial value at present.

The crude oil had specific gravity at 15° C. = 0.9218; rotation  $\alpha_D$  — 9.4°; refractive index at 20° = 1.4877, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 26.7.



On rectification, 2 per cent. distilled below  $169^{\circ}$  C. (corr.). Between  $169$ – $183^{\circ}$ , 48 per cent. distilled; between  $183$ – $224^{\circ}$ , 26 per cent. came over, and between  $224$ – $240^{\circ}$ , 10 per cent. distilled; leaving 14 per cent. boiling above  $240^{\circ}$  C., which consisted largely of the sesquiterpene. The fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8876; rotation  $a_D$  —  $3.73^{\circ}$ .

Second " " " " = 0.8975; "  $a_D$  —  $12.02^{\circ}$ .

Third " " " " = 0.9429; " not taken.

The light did not pass well with the third fraction, but it was strongly lævo-rotatory. The figures show the presence of a considerable amount of aromadendral.

In July, 1910, material of this species was received from near Parramatta, N.S.W., forwarded for distillation by Dr. Cuthbert Hall. The yield of oil was 0.4 per cent. The crude oil was in agreement with that from Barber's Creek, and contained similar constituents in about the same amounts. Cineol did not exceed 10 per cent.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9158; rotation  $a_D$  —  $11.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4606, and was soluble in 1 volume 80 per cent. alcohol. The slightly higher rotation was due to an increased amount of aromadendral.

## 108. *Eucalyptus punctata*, var. *didyma*.

(R.T.B. & H.G.S., in *Euc. and their Ess. Oils*, Edit. 1902, p. 127.)

### Ironwood.

**Systematic.**—This variety is distinguished from the type by its having two opercula to each bud and by the difference in its oil. The outer operculum is thin, and is shed very early in the budding stage, so that it is scarcely ever to be found in herbarium material. The fruit always has a broad groove below the rim, and like the leaves are always larger and thicker than those of the type, while the wood is more open in the grain and less interlocked. Otherwise, morphologically, there is little to distinguish it from the type.

**Habitat.**—Blue Mountains, Rylstone, Barber's Creek, Lismore, Colo Vale, New South Wales.

**ESSENTIAL OIL.**—The oil obtained from this variety of *E. punctata*, from material collected at various localities outside the Sydney district, differed considerably from that obtained from the type growing in the neighbourhood of Sydney. Although the constituents were similar in both cases, yet they varied greatly in the amounts, and the cineol in the oil of the variety was considerably less than in that of *E. punctata* itself.

The presence of aromadendral was very marked, so much so that the odour of the crude oils resembled those obtained from the true "Boxes," rather than from the "Gums." Pinene was present in some quantity, but phellandrene was absent.

Material was obtained from the following localities in New South Wales :— Colo Vale, in July, 1900; Rylstone, in August, 1897, and Barber's Creek, in July, 1898. The oils from these were very similar, and all gave practically the same results. When tabulated it can be seen how well they agree in general characters, although extending over a period of three years, and from three different localities :—

|                                                                        | Yield of Oil<br>per cent. | Specific<br>Gravity at<br>15° C.<br>Crude Oil. | Optical<br>Rotation<br>$a_D$<br>Crude Oil. | Optical<br>Rotation<br>$a_D$<br>(below 183°)<br>first<br>fraction. | Optical<br>Rotation<br>$a_D$<br>(183–245°)<br>second<br>fraction. | Cineol.                 |
|------------------------------------------------------------------------|---------------------------|------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------|
| <i>E. punctata</i> , var. <i>didyma</i> —<br>Rylstone, 3–8–1897. ...   | 0.18                      | 0.9038                                         | — 5.9°                                     | 66 %<br>— 4.3°                                                     | 18 %<br>— 14.5°                                                   | Not exceed-<br>ing 10 % |
| <i>E. punctata</i> , var. <i>didyma</i> —<br>Barber's Creek, 12–7–1898 | 0.28                      | 0.9033                                         | — 5.5°                                     | 69 %<br>+ — 0°                                                     | 19 %<br>— 14.2°                                                   | Not exceed-<br>ing 10 % |
| <i>E. punctata</i> , var. <i>didyma</i> —<br>Colo Vale, 4–7–1900 ...   | 0.37                      | 0.9070                                         | — 4.2°                                     | 73 %<br>+ 0.4°                                                     | 19 %<br>— 15.8°                                                   | About 15%               |

The solubility ranged from 7 volumes 70 per cent. alcohol to 2 volumes 80 per cent. alcohol, and saponification number from 10.9 to 11.6.

This variety of *E. punctata* is apparently a tree not far removed, chemically, from some of the typical "Boxes"; other evidences also go to show the close relationship existing between the "Gums" and the "Boxes."

That alcoholic bodies were present in some quantity is indicated by the results after acetylation of these mixed oils. The saponification number was then 57.6.

## 109. *Eucalyptus rostrata*.

(Schlecht. in Linnea, xx, 655.)

**Murray Red Gum.**

**Systematic.**—A tall tree with a whitish, smooth, persistent bark. Leaves lanceolate, falcate, up to 9 inches long and 1 inch wide, of medium thickness, of equal colour on both sides; venation distinct, lateral veins oblique, spreading, numerous, intramarginal vein removed from the edge. Peduncles axillary, terete or flattened, about 6 lines long, with an umbel of less than a dozen flowers; pedicel almost filiform, and about 4 to 6 lines long, or short and thick. Calyx tube





*EUCALYPTUS ROSTRATA*, SCH.

MURRAY RIVER RED GUM.



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uniformly hemispherical, from  $1\frac{1}{2}$  to 3 lines in diameter; operculum variable in shape, sometimes larger than the calyx, and then it is conical and obtuse, but the most common form is hemispherical, surmounted with a very prominent beak.

**Fruit.**—On a slender pedicel, hemispherical, and consistently so; rim slightly variable in convexity; valves exserted, prominent; 2 to 4 lines in diameter.



*There can be no mistaking this fruit, as it preserves its one form throughout its wide geographical distribution, and wherever planted in other parts of the world it is one of the easiest fruits of the Genus to recognise.*

**Habitat.**—Banks of the Murray, Darling, Lachlan, and Murrumbidgee Rivers and tributaries, and old filled-in water-courses. It is known as "Murray Red Gum" throughout its geographical range.

**REMARKS.**—This Eucalyptus, commonly known as "Murray Red Gum," is the most widely distributed species of the Genus, as it occurs on the banks of almost all the rivers of the interior of the continent. In the State of New South Wales, however, there appear to be two varieties based on the chemical constituents of the oil. Morphologically they seem to be alike, but after our experience with *E. stricta* and *E. apiculata* no doubt some distinguishing form or characters will be found that at present evade detection. The type is here regarded as those trees found on the Murray, Lachlan, and Murrumbidgee Rivers; whilst those growing in more northern localities, such as Nyngan and Broken Hill, are placed as a variety under the name of *E. rostrata* var. *borealis*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were received from Albury, N.S.W., in September, 1899. The yield of oil was 0.14 per cent. The crude oil was red in colour, while that of the rectified oil was yellowish in tint, as is usual with Eucalyptus oils belonging to this group. The oil contained a small amount of phellandrene and some cymene. A small quantity of cineol was present, but not more than 8 to 10 per cent. in the crude oil. The presence of aromadendral was well marked, and it was to the occurrence of this constituent in some quantity that the high lævo-rotation of the oil was due.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.904; rotation  $a_D$  —  $11.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4839, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 10.6.

On rectification 2 per cent. distilled below  $173^{\circ}$  C. (corr.). This portion consisted principally of volatile aldehydes with a little acid water. Between  $173$ – $189^{\circ}$ , 52 per cent. distilled; between  $189$ – $250^{\circ}$ , 18 per cent. came over, and between  $250$ – $260^{\circ}$ , 8 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8725; rotation  $a_D$  —  $10.65^{\circ}$ .

Second " " " " " = 0.8950; " not taken.

Third " " " " " = 0.9362; " "

The higher rotation shown by the crude oil over that of the fraction distilling below  $189^{\circ}$ , was due to the presence of aromadendral in the higher boiling portions.

Material of this species for distillation was also received from Hay, N.S.W., in November, 1900. The yield of oil was 0.28 per cent. In colour, odour, and constituents this oil was similar to that of the same species from Albury, the difference in the time of year probably accounting for the increased yield. A slight increase in the amount of terpenes was shown by the slightly higher rotation, less specific gravity, and an increased amount distilling below  $183^{\circ}$  C.

Cineol, phellandrene, and aromadendral were all detected. The cineol, determined by the phosphoric acid method in the portion distilling below  $183^{\circ}$  C. (65 per cent.), was 19.6 per cent., or about 12 per cent. in the crude oil. The specific gravity of the crude oil = 0.8953, and the optical rotation  $a_D$  —  $14.5^{\circ}$ .

Material of this species for distillation was also obtained from Condobolin, N.S.W., in March, 1901. In appearance, odour, and constituents the oil differed in no respect from the Albury and Hay samples.

The above samples were mixed and stored in the dark, and in October, 1919, nineteen years afterwards, the oil was again analysed. But little alteration had taken place during that period, although perhaps a slight increase in cineol content had taken place, but the present determination was made by the resorcinol method in the fractionated portion, and then only indicated 20 per cent. in the crude oil.

On rectification 72 per cent. distilled below  $190^{\circ}$  C. The crude oil and the fraction gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9040; rotation  $a_D$  —  $14^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4830.  
 Large fraction „ „ = 0.8847; rotation  $a_D$  —  $13.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4773.

The aromadendral was quite as pronounced as when the oils were freshly distilled.

Later, in June, 1911, leaves and terminal branchlets of this species for distillation were collected at the Kingscote end of Kangaroo Island, South Australia.

The yield of oil from this material was 0.38 per cent. Cineol was present, but in small amount, and a small quantity of phellandrene was also detected; cymene was present in some quantity. The oil from this material gave results which were in close agreement with those published in the first edition of this work, and again recorded above.

The crude oil of the Kangaroo Island *E. rostrata* had specific gravity at  $15^{\circ}$  C. = 0.9047; rotation  $a_D$  —  $12.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4890, and was soluble in one volume 80 per cent. alcohol. The saponification number for the esters and free acid was 6.1.

On rectification about 2 per cent. of acid water and some aldehydes came over below  $173^{\circ}$  C. (corr.). Between  $173$ – $188^{\circ}$ , 51 per cent. distilled; between  $188$ – $255^{\circ}$ , 30 per cent. came over, and between  $255$ – $272^{\circ}$ , 7 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8710; rotation  $a_D$  —  $7.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4811.  
 Second „ „ „ = 0.9127; rotation  $a_D$  —  $21.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4929.  
 Third „ „ „ = 0.9333; rotation not taken; refractive index at  $20^{\circ}$  = 1.5040.

The left rotation of the first fraction was partly due to the phellandrene, while that of the second fraction was almost entirely owing to the aromadendral. The high refractive index of the first fraction, taken in conjunction with the low specific gravity, was evidently due to the influence of the cymene.



The cineol was determined by the resorcinol method in the first fraction; when calculated for the crude oil the result was 11 per cent.

For the determination and identification of the low-boiling constituents in the oil of this species another portion was distilled. The oil which came over below 185° C. was added to that of the first distillation, and the whole refractionated, using a rod and disc stillhead. Although commencing to distil at 157°, yet only 7 per cent. came over below 170° C. (corr.); but at 173°, 38 per cent. had distilled. The three fractions were separated as follows:—157–173°, 38 per cent.; 173–175°, 31 per cent.; 175–179°, 15 per cent.; residue boiling above 179°, 16 per cent. The fractions and residue gave the following results:—

|                             |                                                                                      |
|-----------------------------|--------------------------------------------------------------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8647; rotation $a_D$ — 4.5°; refractive index at 20° = 1.4777. |
| Second     ,,     ,,     ,, | = 0.8676; rotation $a_D$ — 6.4°; refractive index at 20° = 1.4806.                   |
| Third     ,,     ,,     ,,  | = 0.8714; rotation $a_D$ — 7.2°; refractive index at 20° = 1.4812.                   |
| Residue     ,,     ,,       | = 0.9063; rotation $a_D$ — 17.8°; refractive index at 20° = 1.4880.                  |

It was thus evident that the amount of pinene could be but small, and that it was either inactive or slightly lævo-rotatory. The high refractive index, and low specific gravity, suggests the presence of cymene. Phellandrene was detected in all three fractions.

Cineol was also detected in all three fractions, and as this constituent was small in amount it was removed by agitating each fraction with 50 per cent. resorcinol and the uncombined portions washed and dried. The influence of the cineol is shown from the following figures, when compared with those given above:—

|                             |                                                               |
|-----------------------------|---------------------------------------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8613; refractive index at 20° = 1.4805. |
| Second     ,,     ,,     ,, | = 0.8649; refractive index at 20° = 1.4842.                   |
| Third     ,,     ,,     ,,  | = 0.8667; refractive index at 20° = 1.4856.                   |

*Cymene*.—The determination of the results as recorded above suggested the presence of cymene, and to arrive at the identity of this hydrocarbon, the fraction of the rectified oil, thought to contain cymene in greatest quantity, was oxidised by an aqueous solution of potassium permanganate (12 grams  $\text{KMnO}_4$  in 330 grams water), as suggested by Wallach; about 2 grams of oil at the time were added, and the solution heated on a rapidly boiling water-bath. When the reaction was completed the precipitate was filtered off, the filtrate evaporated to dryness, the salt boiled out by alcohol, evaporated to small bulk, water added and acidified with sulphuric acid. The separated acid was purified from alcohol; it then melted at 155–156° C. From the method of formation, and its melting point, there seems little doubt but that the acid formed was p-oxyisopropylbenzoic acid. This result, together with other factors, indicates the presence of p-cymene in some quantity in the oil of *E. rostrata*.

It will thus be seen that this oil differs entirely from that derived from its variety *borealis*.

(For the determination of the aromadendral see the article in this work on "The cyclic (aromatic) aldehydes occurring in Eucalyptus oils.")

## 110. *Eucalyptus propinqua*.

(H.D. & J.H.M., in Proc. Linn. Soc., N.S.W., 1895, p. 541, t. XLIII.)

Grey Gum of the North Coast, N.S.W.

**Systematic.**—A large, straight growing tree, found up to 4 or 5 feet in diameter, and 120 feet and more in height. The bark is grey, dirty-looking, and peels off in large, longitudinal, irregular patches, leaving a smooth, white surface. The bark closely resembles, and is, perhaps, not to be distinguished from that of *E. punctata*. Abnormal leaves more broadly lanceolate, and with the marginal vein more distinct from the edge than in the case of normal leaves, at first opposite. Normal leaves narrow-lanceolate and very uniform, average length 4 to 5 inches, breadth  $\frac{3}{4}$  inch; venation not prominent, lateral veins nearly parallel, intramarginal vein on or very close to the edge of the leaf as a general rule. Peduncles flattened. Flowers pedicellate, usually in tens, but sometimes as few as five. Calyx tube hemispherical and longer than the operculum, which is hemispherical, but with a low pointed apex.

**Fruit.**—On angular pedicels about 2 lines long, hemispherical, small, occasionally slightly ribbed, very uniform in size; rim thick; valves exserted; about  $2\frac{1}{2}$  lines broad by  $1\frac{1}{2}$  lines deep.



*The fruits, as regards the rim and general contour, considerably resemble those of the smaller forms of E. resinifera, E. maculosa, and perhaps E. dealbata.*

**Habitat.**—Coast Districts of New South Wales.

**REMARKS.**—The affinities of *E. propinqua* are with *E. saligna* and *E. punctata*, contiguous species in Baron von Mueller's Census. A very distinct species and easily recognised by its small fruits and red timber, which is of excellent quality. The timber is dark coloured, and so closely resembling "Red Ironbark" (*E. siderophloia*) that care is required to distinguish the two timbers. Very durable in or out of the ground, but its tensile strength inferior to that of the "Ironbark" already referred to.—H.D. & J.H.M.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were collected at Woodburn, N.S.W., in August, 1900. The yield of oil was 0.24 per cent. The crude oil was red in colour, and had a turpentine-like odour. It contained no phellandrene, but pinene was present in some quantity; cineol occurs, but that constituent was not present in sufficient amount for the oil to be of commercial value, even if the yield had been higher. Aromadendral was detected in the higher boiling portion, and this constituent was also indicated by the lævo-rotation of the second fraction.

The crude oil had specific gravity at 15° C. = 0.8980; rotation  $\alpha_D + 4.4^\circ$ ; refractive index at 20° = 1.4731, and was soluble in 8 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.4.







**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were received from Ourimbah, N.S.W., in September, 1897. The yield of oil was 0.6 per cent. The crude oil was of an orange-brown colour, and had an odour not at all unlike those of the "Box" group generally. The oil of this species had a strong resemblance to that of *E. punctata* var. *didyma*, and contained aromadendral in some quantity. The constituents present, besides the aromadendral, were pinene, cineol, cymene, esters, and the sesquiterpene. Phellandrene was absent.

The crude oil had specific gravity at 15° C. = 0.9216; rotation  $a_D = 3.2^\circ$ ; refractive index at 20° = 1.4896, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 21.4.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–183°, 37 per cent. distilled; between 183–224°, 36 per cent. came over; between 224–250°, 10 per cent. distilled, and between 250–279°, 7 per cent. These fractions gave the following results:—

|                 |                             |                              |
|-----------------|-----------------------------|------------------------------|
| First fraction, | sp. gr. at 15° C. = 0.8821; | rotation $a_D = 4.1^\circ$ . |
| Second "        | " " " = 0.8847;             | " " " = 8.2°.                |
| Third "         | " " " = 0.9559;             | " " " = 22.5°.               |
| Fourth "        | " " " = 0.9440;             | " " " too dark.              |

The influence of the aromadendral in the third fraction evidently accounts for its higher specific gravity over that of the fourth fraction.

The cineol in the crude oil did not exceed 8 or 10 per cent.

## 112. *Eucalyptus Rudderi*.

(J.H.M., in Proc. Linn. Soc., N.S.W., 1904, p. 779.)

**Red Box.**

**Systematic.**—A tree reaching 120 feet in height and 2 to 3 feet in diameter, the bark somewhat like the ordinary "Grey Box," *E. hemiphloia*, (J.H.M.). Leaves lanceolate, acuminate, up to 5 inches long; venation fairly distinct, intra-marginal vein varying in distance from the edge, lateral veins fairly numerous, inclined at 45° to the mid-rib. Inflorescence paniculate, peduncle 4 lines long, with umbels of small flowers. Calyx tube  $1\frac{1}{2}$  lines long, tapering to a pedicel of about equal length; operculum conoidal.

**Fruit.**—Conoid or somewhat pyriform, on slender pedicels; rim thin; valves not exserted; 2 lines long and under 2 lines in diameter.



*It is almost impossible to morphologically separate these fruits from those of E. crebra.*

**Habitat.**—The Coastal districts of New South Wales, but favouring the northern portion.

**REMARKS.**—Although the fruits of this species and *E. crebra* are practically identical in form, yet this tree has a "Box" bark and the latter, *E. crebra*, is an "Ironbark."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were received from Thirlmere, N.S.W., in September, 1906. The yield of oil was 0.31 per cent. The crude oil was of a light reddish-brown colour, and had the characteristic appearance and odour of the typical "Box" oils generally. The secondary odour of aromadendral was very pronounced. Pinene was only present in small amount and phellandrene was absent. Cineol was detected, but only to the extent of 5 to 8 per cent. Cymene was a pronounced constituent. Altogether the results show this oil to be closely associated with those of *E. hemiphloia*, *E. Woollsiana*, &c.

The crude oil had specific gravity at 15° C. = 0.9042; rotation  $a_D$  — 8.5°; refractive index at 20° = 1.4841, and was soluble in 1 volume 80 per cent. alcohol.

On rectification, 2 per cent. distilled below 171° C. (corr.). Between 171–178°, 35 per cent. distilled, and between 178–205°, 37 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8893; rotation  $a_D$  — 1.7°.

Second " " " " = 0.9130; " " — 6.8°.

The lævo-rotation of this oil is due to the aromadendral. Esters were only present to a small extent, as the saponification number was 6.1.

### 113. *Eucalyptus salubris*.

(F.v.M., in *Fragm. x.* 54, 1876.)

**Gimlet Gum.**

**Systematic.**—A tall tree, with a smooth, thin bark, stem usually much twisted. Branchlets often green in colour. Abnormal leaves ovate-lanceolate, petiolate. Normal leaves small, lanceolate, acuminate, shining, older leaves particularly so; venation more prominent in younger leaves, intramarginal vein close to the edge, lateral veins spreading, inclined at about 30° to the mid-rib. Peduncles flattened, about 3 lines long, at first axillary, later lateral, with umbels of three to six flowers. Buds shining; calyx tube about 1 line long, semi-ovoid, pedicel twice as long; operculum blunt, conoidal, 2 lines in length.

**Fruit.**—Small, truncate, pyriform, tapering to a short angular pedicel, shining; rim convex; valves slightly exserted; 2 lines long and 2 lines in diameter.



*The capsule comes closer in form to that of E. squamosa than perhaps to any other species.*

**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Material for distillation was received from Western Australia in July, 1904. It was collected at Hine's Hill, Great Eastern Railway, and consisted of leaves and terminal branchlets cut as would be done for commercial purposes. The yield of oil was 1.39 per cent. The crude oil was of a light reddish-brown colour, and had a very distinct odour of



aromadendral. It contained pinene, which was apparently the dextro-rotatory form; phellandrene was absent, as was to be expected in this class of Eucalyptus oils. Cymene was present in some quantity. Cineol was detected, but it only occurs in the oil of this species in comparatively small amount. Aromadendral was present in considerable quantity, and it was to this constituent that the lævo-rotation of the oil was due.

The esters consisted largely of geranyl-acetate.

It is worthy of note how closely the oil of this species agrees with those from the typical "Boxes" of the eastern coast of Australia, and of many of the "Mallees."

The crude oil had specific gravity at 15° C. = 0.902, rotation  $a_D$  — 5.8°; refractive index at 20° = 1.4784, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 18.9.

On rectification, the usual amount of volatile aldehydes came over below 168° C. (corr.). Between 168–172°, 18 per cent. distilled; between 172–183°, 46 per cent. distilled; between 183–219°, 18 per cent. came over, and between 219–240°, 9 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8848; rotation  $a_D$  + 6.8°.

Second " " " = 0.8898; " + 0.5°.

Third " " " = 0.9030; " — 8.9°.

Fourth " " " = 0.9395; " — 30.1°.

The cineol, determined by the phosphoric acid method in the second fraction, was 18.8 per cent., representing about 10 per cent. of that constituent in the crude oil.

For the investigation of the aromadendral, see the article in this work, on "The cyclic (aromatic) aldehydes occurring in Eucalyptus oils."

There is little demand for this class of Eucalyptus oil at present, although Dr. Cuthbert Hall has shown\* that aromadendral has marked bactericidal properties, far greater than those of any other constituent in Eucalyptus oils. If not suitable for medicinal purposes, such Eucalyptus oils, with a high aromadendral content, might well be utilised for disinfectants, and also for soaps and similar articles.

The results obtained with the oil of this species were published by us in the *Pharmaceutical Journal*, London, September, 1905.

## 114. *Eucalyptus occidentalis*.

(Endl., in Hueg. Enum., 49, 1837.)

**Systematic.**—A tree sometimes reaching a height of 120 feet, but often found flowering when quite small. Abnormal leaves broad, ovate, cordate, somewhat acute. Normal leaves broad to narrow-lanceolate, usually under 6 inches long, acuminate, sometimes falcate, older leaves shining and coriaceous; venation not prominent in the older leaves, intramarginal vein removed from the edge, lateral veins fine, distant, spreading, usually at an angle of 30° to the mid-

\* Eucalyptus oils, especially in relation to their bactericidal power.



rib. Peduncles axillary or lateral, flattened, recurved, up to 12 lines long, with umbels of from three to six flowers. Buds on thick pedicels, 2 to 3 lines long; calyx tube somewhat bell-shaped, 3 lines in length and half as long as the blunt sub-cylindrical operculum.

**Fruit.**—Inclined to bell-shaped, but somewhat conical, slightly ribbed, length of pedicel variable; rim inclined to flat or only slightly convex; valves acuminate, recurved, well exerted; often 6 lines long and 5 lines in diameter.



*The fruits are fairly characteristic and not easily confounded with those of any other species.*

**Habitat.**—South west of Western Australia.

**REMARKS.**—A species easily determined in the field and herbarium. In the young or early trees the bark is inclined to be smoothish, when it is collected and placed on the market as "Mallet bark." In the case of the more mature trees the bark becomes rough and is not collected for tanning purposes, the percentage of tannin of course being less owing to the outer corky ridges, in which case there seems no reason why "rossed" bark should not be used for tanning.

**ESSENTIAL OIL.**—Material for distillation was forwarded from Western Australia in June, 1904. It was collected at Narrogin, on the Great Southern Railway, and consisted of leaves and terminal branchlets collected as for commercial distillation. The yield of oil was 0.95 per cent. The crude oil was reddish in colour and had an odour resembling the cineol-pinene oils generally, with a secondary one indicating aromadendral. Pinene was found in some quantity, and it belonged principally to the dextro-rotatory form; phellandrene was absent. More than a third of the oil consisted of cineol, and a large amount of the sesquiterpene was also present. The higher boiling constituents were in such quantity that only 75 per cent. of the oil distilled below 183°. The esters were small in amount, and the volatile aldehydes not at all pronounced. The presence of aromadendral, together with other characters, suggest that the species approaches somewhat closely the group of typical "Boxes," such as *E. hemiphloia*, &c.

The oil of this species has no special properties, and at present has little value for commercial purposes.

The crude oil had specific gravity at 15° C. = 0.9135; rotation  $a_D + 9.0^\circ$ ; refractive index at 20° = 1.4717, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 2.5.

On rectification, 1 per cent. distilled below 165° C. (corr.). Between 165–172°, 44 per cent. distilled; between 172–183°, 30 per cent. came over; between 183–228°, 10 per cent. distilled, and between 228–264°, 10 per cent. distilled. These fractions gave the following results:—

|                     |                                     |                                      |
|---------------------|-------------------------------------|--------------------------------------|
| First fraction,     | sp. gr. at 15° C. = 0.8981;         | rotation $a_D + 17.7^\circ$ .        |
| Second    "       " | "       "       "       " = 0.9134; | "       "       "       " + 8.2°.    |
| Third     "       " | "       "       "       " = 0.9329; | "       "       "       " — 3.2°.    |
| Fourth    "       " | "       "       "       " = 0.9415; | "       "       "       " not taken. |

The lævo-rotation shown by the third fraction, was due to the aromadendral.

The cineol was determined by the phosphoric acid method; the result was 36 per cent. (O.M.)

The results obtained with the oil of this species were published by us in the *Pharmaceutical Journal*, London, September, 1905.

## 115. *Eucalyptus exserta*.

(F.v.M., in Jour. Linn. Soc., 1859, iii, 85.)

**Systematic.**—A small tree, with an ash-brown, scaly, wrinkled and fissured bark, persistent on trunk and branches. Leaves alternate, narrow-lanceolate, elongated, falcate, acuminate, 3 to 6 inches long, and 4 to 8 lines broad; venation not prominent, intramarginal vein distant from the edge. Umbels axillary or lateral, three- to seven-flowered, peduncles angular, 3 to 5 lines long. Calyx tube hemispherical, indistinctly ribbed, shortly pedicellate, half as long as the conical, somewhat obtuse operculum.

**Fruit.**—Hemispherical; rim broad and very prominent, almost conical; valves much exserted; 3 to 4 lines in diameter.

*The fruits show a great resemblance to those of E. tereticornis and E. rostrata, but the bark differentiates it from each, being closely allied to the "Bloodwoods."*



**Habitat.**—Eastern portion of Queensland.

**ESSENTIAL OIL.**—Leaves and terminal branchlets of this species for distillation were received from the Boyne River, Gladstone, Queensland, in September, 1908. The material was sent by Mr. H. S. Owbridge, through Mr. McMahon, the late Director of Forests for that State. The yield of oil was 0.82 per cent.

This Eucalypt is known in the Boyne River District as "Peppermint," but the oil has no resemblance to those of the members of the "Peppermint" group growing in the Southern States.

The crude oil was reddish in colour, and had an odour resembling the cineol-pinene oils generally. The constituents present were cineol, pinene, aromadendral, and the sesquiterpene; volatile aldehydes were pronounced, and cymene was probably also present.

The crude oil had specific gravity at 15° C. = 0.8977; rotation  $a_D + 12.2^\circ$ ; refractive index at 20° = 1.4729, and was soluble in 5 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.7.

On rectification, 2 per cent. distilled below 161° C. (corr.). Between 161–167°, 40 per cent. distilled; between 167–174°, 24 per cent. came over; between 174–183°, 16 per cent. distilled; between 183–228°, 8 per cent. distilled, and between 228–255°, 6 per cent. These fractions gave the following results:—

|                                                                                                             |   |   |                                                                           |
|-------------------------------------------------------------------------------------------------------------|---|---|---------------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. = 0.8833; rotation $a_D + 19.8^\circ$ ; refractive index at 20° = 1.4689. |   |   |                                                                           |
| Second                                                                                                      | „ | „ | = 0.8902; rotation $a_D + 14.5^\circ$ ; refractive index at 20° = 1.4703. |
| Third                                                                                                       | „ | „ | = 0.9039; rotation $a_D + 3.9^\circ$ ; refractive index at 20° = 1.4719.  |
| Fourth                                                                                                      | „ | „ | = 0.9310; rotation $a_D - 7.6^\circ$ ; refractive index at 20° = 1.4821.  |
| Fifth                                                                                                       | „ | „ | = 0.9485; rotation $a_D - 2.0^\circ$ ; refractive index at 20° = 1.5005.  |

The cineol was determined by the phosphoric acid method; the result was 29 per cent. in the crude oil.

The lævo-rotation of the higher fractions was due to the aromadendral. The oil of this species does not contain phellandrene, nor was eudesmol detected.



## 116. *Eucalyptus marginata*.

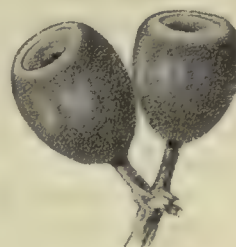
(Sm., in Trans. Linn. Soc., vi, 302, 1802.)

Jarrah.

**Systematic.**—A large tree, averaging 100 feet in height, the bark persistent and fibrous, but being flaky it is not a true "Stringybark." Leaves ovate-lanceolate or lanceolate, under 5 inches long, acuminate, falcate, paler underneath; venation prominent, the intramarginal vein looped and well removed from the edge or often quite close, lateral veins numerous, fairly transverse. Peduncles slender, axillary, up to 12 lines in length, with umbels of three to twelve flowers. Buds on pedicels 2 to 3 lines long; calyx tube turbinate, and half as long as the conical, obtuse operculum.

**Fruit.**—Ovoid-truncate, contracted at the top; rim incurved and later depressed; valves small, not or only slightly exerted; about 9 lines long and 8 lines in diameter.

*As a carpological specimen it stands alone in form amongst Eucalyptus fruits.*



**Habitat.**—Western Australia.

**ESSENTIAL OIL.**—Material was received for distillation from Western Australia in June, 1904. Two consignments were forwarded, one collected on the Darling Ranges, the other from the sandy flat country around Perth. The first consisted of leaves from older trees, and was a fair average sample, the other was composed principally of abnormal leaves. Although necessarily a great diversity in material was thus shown, as well as a difference in environment, yet the oils were in very close agreement, both in their chemical and physical properties. A larger amount of the lower-boiling terpenes was present in the oil from the abnormal leaves than in that from the older leaves, although the constituents were the same in both samples. This decrease in the amount of the characteristic low-boiling terpene in the older leaves is usual with most *Eucalyptus* species, and numerous instances of this fact are recorded throughout this work. We have shown also that the characteristic constituents for the oils of any species are common to both young and old leaves, the variation being in the amount.

The crude oils were red in colour, and had an odour indicating aromadendral. The oil from the "Jarrah" is closely associated with those of such species as the type *E. tereticornis* and *E. punctata* var. *didyma*, and there is strong evidence to support the idea that this class of trees is more closely associated with those *Eucalypts* known as "Boxes" than to any other group. Phellandrene could not be detected, nor was it to be expected in this class of *Eucalyptus* trees. Pinene was present in small amount, while cymene was a pronounced constituent. The amount of cineol was less than 10 per cent. in the first fraction,



The sesquiterpene was also present. The higher-boiling portion came over as a deep-blue oil; this peculiarity has often been noticed with the oils of certain *Eucalyptus* species, particularly in the portion distilling at about 250–280° C. The aromadendral was extracted from the mixed third fractions in the usual way, its oxime prepared, and its other characteristics determined.

When the results obtained with these two samples of oil are tabulated, it is seen how closely they agree.

|                                                | Darling Range Sample. | Perth Sample.        |
|------------------------------------------------|-----------------------|----------------------|
| Amount distilling between 169–183° C. ...      | 57 per cent.          | 65 per cent.         |
| „ „ 183–214° C. ...                            | 21 „                  | 18 „                 |
| „ „ 214–245° C. ...                            | 10 „                  | 8 „                  |
| „ „ 245–252° C. ...                            | 4 „                   | .....                |
| First fraction :—                              |                       |                      |
| Specific gravity at 15° C. ...                 | 0·8793                | 0·8705.              |
| Optical rotation $a_D$ ...                     | — 7·1°                | — 8·2°               |
| Refractive index at 20° C. ...                 | 1·4864                | 1·4838               |
| Second fraction :—                             |                       |                      |
| Specific gravity at 15° C. ...                 | 0·8974                | 0·8792               |
| Optical rotation $a_D$ ...                     | — 6·7°                | — 9·2°               |
| Third fraction :—                              |                       |                      |
| Specific gravity at 15° C. ...                 | 0·9437                | 0·9437               |
| Optical rotation $a_D$ ...                     | — 14·6°               | — 16·8°              |
| Crude oil :—                                   |                       |                      |
| Specific gravity at 15° C. ...                 | 0·9117                | 0·8889               |
| Optical rotation $a_D$ ...                     | — 8·5°                | — 10·4°              |
| Refractive index at 20° C. ...                 | 1·4889                | 1·4889               |
| Saponification number for esters and free acid | 13·1                  | 10·3                 |
| Solubility in alcohol ...                      | 1 vol. 80 per cent.   | 5 vols. 80 per cent. |
| Yield of oil ...                               | 0·24 per cent.        | 0·2 per cent.        |

The high lævo-rotation of the higher-boiling fractions was due to the aromadendral, and this influence was also shown in the crude oils.

The esters were entirely saponified in the cold with two hours' contact, giving an aromatic oil with a strong resemblance to geraniol; the acid was acetic. It is thus probable that the ester was geranyl-acetate.

The results obtained with these oils were published by us in the *Pharmaceutical Journal*, London, September, 1905.

## 117. *Eucalyptus affinis*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1900, p. 104, t. V.)

**Systematic.**—A tree of moderate size, attaining a height of 80 feet and a diameter of 2 feet 6 inches. The bark in appearance looks half "Ironbark" and half "Box," and has strong affinities to both. Abnormal leaves alternate, ovate, obtuse, slightly emarginate, and mucronate, about 3 inches long by  $1\frac{3}{4}$  inch broad; intramarginal vein at a considerable distance from the edge. Normal leaves lanceolate, slightly falcate, pale-coloured, dull on both sides, rather coriaceous, usually 2 to 3 inches long; lateral veins at an angle of  $30^\circ$  with the mid-rib, but inconspicuous except the mid-rib and thickened margins, intramarginal vein indistinct and at some distance from the edge. Peduncles axillary, flattened at first, but nearly terete when the fruit is ripe, with three to seven flowers. Calyx tube attenuate, tapering into a short pedicel; the operculum attenuate.

**Fruit.**—Ovate-truncate, tapering at the base, somewhat contracted at the orifice; rim narrow, truncate, slightly convex and dark-coloured; valves depressed; about 3 lines in diameter.



*Some of the fruits are uncommonly like those of E. albens, as also are the buds.*

**Habitat.**—Wellington and Dubbo, towards Molong and Parkes, Grenfell, and in other parts of the western districts of New South Wales.

**REMARKS.**—The true affinities of the species are in the opinion of Deane and Maiden (*loc. cit.*) with *E. sideroxylon*, A. Cunn., and *E. hemiphloia*, F.v.M. Mr. Cambage is of opinion that the tree is a hybrid between *E. hemiphloia*, or *E. albens*, and *E. sideroxylon*. Botanically it is close to *E. albens*, the thick, deeply furrowed bark being the only feature of differentiation. The timber of *E. affinis* varies, sometimes it is nearly as red as *E. sideroxylon*, sometimes much paler, approaching that of *E. melliodora*, and sometimes it is pale with red streaks or patches intermixed. In general aspect *E. affinis* is more like *E. albens*, and would never be mistaken for *E. melliodora* or for *E. hemiphloia*. The result of our investigations shows it to have little connection with the group of "Boxes" to which *E. albens* or *E. hemiphloia* belong.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Grenfell, N.S.W., in April, 1901. The yield of oil was 0.26 per cent. The crude oil was of a reddish orange-brown colour, and had an odour resembling those belonging to the cineol-pinene class. Volatile aldehydes were not pronounced. Cineol was detected, but not in large amount. Pinene was present, but phellandrene was absent. The principal constituent in this oil was the sesquiterpene, and this, of course, caused the crude oil to have a high viscosity, a high specific gravity, and to boil at a high temperature. It is probable that aromadendral was present also, judging from the lævo-rotation of the second fraction and the odour.

The crude oil had specific gravity at  $15^\circ$  C. = 0.9259; rotation  $\alpha_D + 5.6^\circ$ ; refractive index at  $20^\circ$  C. = 1.4864, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 4.7.



On rectification, the usual amount of acid water and volatile aldehydes came over below  $165^{\circ}$  C. (corr.). Between  $165$ – $183^{\circ}$ , 39 per cent. distilled; between  $183$ – $244^{\circ}$ , 17 per cent. came over, and between  $244$ – $270^{\circ}$ , 35 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. =  $0.8964$ ; rotation  $a_D + 1.3^{\circ}$ .  
 Second „ „ „ =  $0.9102$ ; „ —  $2.3^{\circ}$ .  
 Third „ „ „ =  $0.9477$ ; „ not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 29 per cent., or about 14 per cent. in the crude oil (O.M.)

This sample of oil had been kept in the dark, and in September, 1919, 18 years afterwards, was again analysed. Comparatively little alteration had taken place during that time, although the specific gravity had increased, and the rotation diminished a little. 42 per cent. distilled below  $190^{\circ}$  C. The crude oil and the fraction below  $190^{\circ}$  gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. =  $0.9328$ ; rotation  $a_D + 4.1^{\circ}$ ; refractive index at  $20^{\circ}$  =  $1.4869$ .

Fraction „ „ =  $0.9020$ ; rotation  $a_D + 2.2^{\circ}$ ; refractive index at  $20^{\circ}$  =  $1.4684$ .

The cineol, determined by the resorcinol method in the oil distilling below  $190^{\circ}$ , and calculated for the crude oil, was 28 per cent. By the phosphoric acid method it was 19 per cent.

## 118. *Eucalyptus Fletcheri*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1901, p. 682, t. XIV.)

**Lignum-vitæ or Box.**

**Systematic.**—A medium-sized tree, with a “Box” bark on the trunk; branches smooth, branchlets glaucous. Leaves from orbicular to ovate-acuminate in shape, sometimes oblique, cuneate or rounded at the base, from 1 to 3 or 4 inches in width, thin, not shining; venation faintly marked, lateral veins oblique, spreading, intramarginal vein removed from the edge, but more pronounced at the base, giving a trinerved appearance to the leaf. Flowers numerous in axillary or terminal panicles. Peduncles short, 2 to 3 lines long. Buds about 5 lines long; calyx tube conical, with scarcely any pedicel; operculum hemispherical, very shortly acuminate or obtuse.

**Fruit.**—Conical, tapering to a short pedicel; rim very thin and countersunk, mostly in mature fruits with a notch; valves inserted; about 4 lines long, and 3 lines broad.

*The fruits of E. conica are almost identical in shape with these.*



**Habitat.**—South Creek, St. Mary's (N. V. Fletcher); banks of the Nepean River; Thirlmere, New South Wales; Gippsland Lakes Entrance, Heyfield, and Bruthera, Victoria.



**REMARKS.**—A tree as far as at present known restricted in its geographical distribution to the watershed of the Nepean River of New South Wales, and Gippsland, Victoria. The late Dr. Woolls was very probably the first to collect material of this tree for botanical determination, and to forward it to Mueller under the local name of *Lignum-vitæ* ("Eucalyptographia," Dec., iii). This latter author, working on morphological grounds, confounded it with the "Red Box" *E. polyanthemos*, Schau. The dried specimens of the two species are very much alike in the shape of the leaves and fruits, but the trees differ considerably in other characters. For instance, the "Red Box" has a persistent "Box" bark right out to the branchlets, a dark-red timber, and leaves larger than those of this species. This tree has thick, rough, flaky bark. The two timbers alone are sufficient to differentiate the trees, and the essential oils possess quite distinct chemical constituents. This is another example showing how necessary it is that field and other observations are required in order to determine correctly the specific rank of Eucalypts. This species generally occurs on the banks of rivers and creeks. It differs from *E. polyanthemos* in the colour of the timbers. Maiden (Crit. Rev. Euc. vol. ii, p. 120), places this species under *E. Baueriana*, which was founded on an imperfect description and specimen "in plump bud and an expanded flower"—surely worthless data upon which to perpetuate a systematic name. *E. Baueriana* is a tropical species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Thirlmere, N.S.W., in July, 1900. The yield of oil was 0.3 per cent. The colour of the oil was orange-brown, and the odour somewhat rank. The oil contained a good quantity of phellandrene; and pinene was present in small amount; cineol was detected, but only about 5 to 10 per cent. in the crude oil at time of distillation. Aromadendral was also detected. The sesquiterpene was present in some quantity, but esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.8805; rotation  $a_D$  — 12.5°; refractive index at 20° = 1.4824, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 3.3.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–183°, 48 per cent. distilled; between 183–255°, 22 per cent. came over, and between 255–276°, 16 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8624; rotation  $a_D$  — 16.9°.

Second " " " = 0.8697; " — 16.5°.

Third " " " = 0.9378; " not taken.

The lævo-rotation was largely due to the phellandrene. As only 1 per cent. distilled between 200–255° C., the aldehyde aromadendral could only be present in small amount.

Leaves from this species were also obtained from St. Mary's, N.S.W., in November, 1900. The oil differed but little from the Thirlmere sample; it contained similar constituents, and the several fractions were lævo-rotatory to about the same extent, but the aldehyde aromadendral was present in rather larger amount. The specific gravity of the crude oil was 0.895. The cineol present was about the same as in the previous sample; the saponification number for the esters and free acid was 3.5. The crude oil formed a clear solution with 2 volumes 80 per cent. alcohol.

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. Not much alteration had taken place during the nineteen years the oil had been kept, except that the rotation had fallen a little, and the specific gravity increased to a small extent. These alterations are what might be expected with Eucalyptus oils in which phellandrene occurs.

The crude oil had sp. gr. at 15° C. = 0.8912; rotation  $a_D$  — 10.0°; refractive index at 20° = 1.4820.

Rectified portion " " " = 0.8726; rotation — 13.5°; refractive index at 20° = 1.4755.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 17 per cent. The indication with phosphoric acid was for about 10 per cent. of that constituent.

## 119. *Eucalyptus Woollsiana*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 684, t. XLIII.)

### Mallee Box.

**Systematic.**—A large tree, up to 80 feet high, and more than 3 feet in diameter. Bark persistent half-way or more up the trunk, smooth, chiefly of a rich brown colour. Abnormal leaves lanceolate, alternate, 2 to 3 inches long, 6 to 9 lines broad. Normal leaves under 6 inches long, on a petiole less than 6 lines long, narrow-lanceolate, tapering to a fine recurved point, mostly of a thin texture, of a light-yellowish green, generally shining; venation slightly obscured, impressed on the upper surface, lateral veins few, intramarginal vein removed from the edge. Peduncles axillary, from 2 to 12 lines long. Flowers few. Calyx tube about 1 line in diameter, tapering into a short stalk; operculum hemispherical, acuminate, and often *more obtuse than shown in the plate*.

**Fruit.**—Mostly pear-shaped, only occasionally hemispherical; rim thin, slightly contracted; valves not exserted; about 3 lines in diameter.



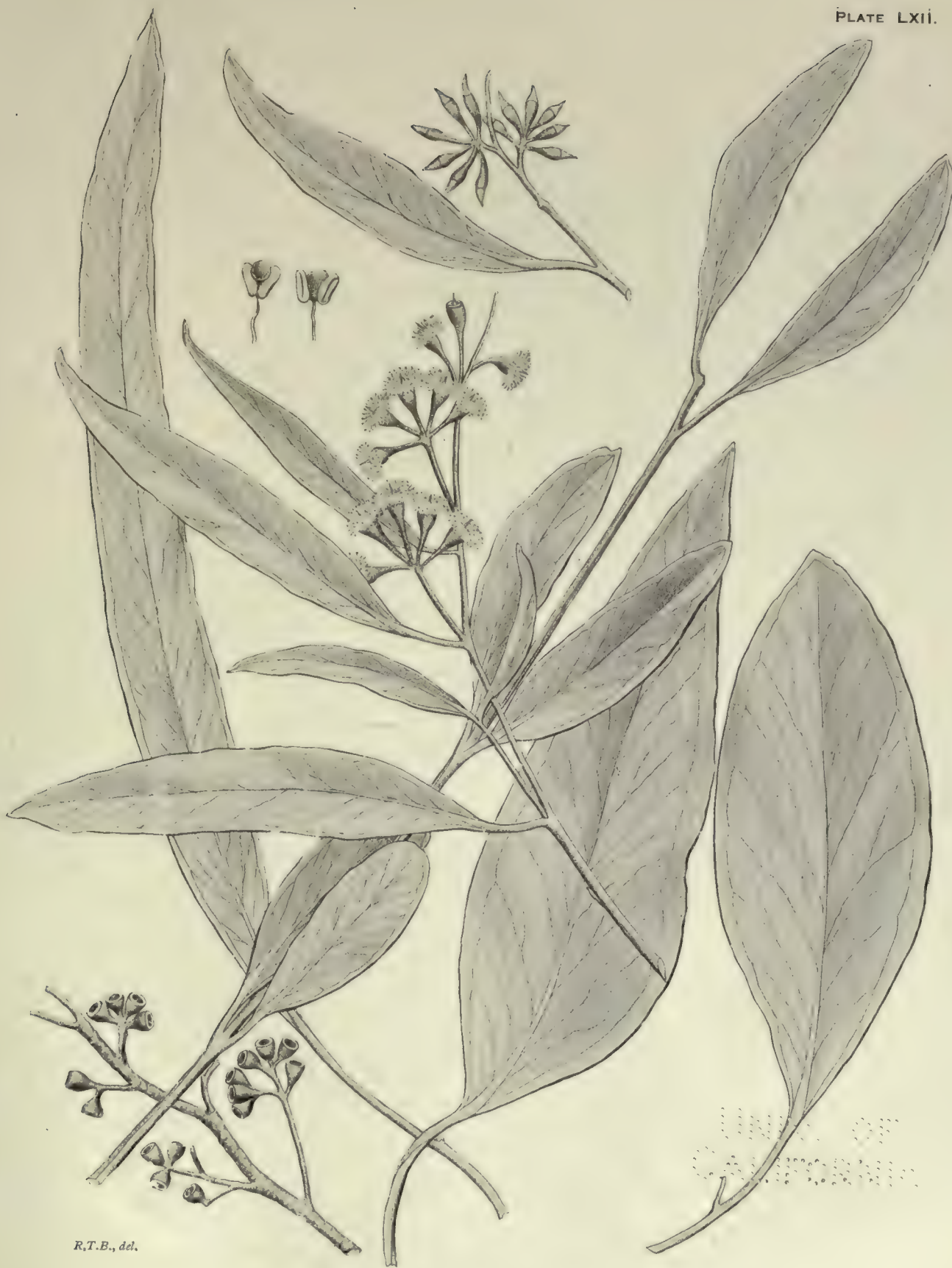
*The fruits greatly resemble those of E. polybractea, but differ in shape from most of those of other "Boxes" such as E. hemiphloia and E. odorata.*

**Habitat.**—Girilambone, Cobar, Trangie, Nyngan, Murga, New South Wales; also interior of Victoria.

**REMARKS.**—The tree is a half-barked "Box," and allied in bark, timber and oil to other cognate "Box" trees. The leaves have not a shining surface as obtains in *E. populifolia*, F.v.M., and *E. Behriana*, F.v.M. It differs from *E. microtheca* in the valves of the fruits not being exserted, in the colour of the wood, and in the bark, and chemical constituents. From *E. hemiphloia* it differs in the nature of its timber, buds and leaves; from *E. bicolor*, A. Cunn., in the venation and shape of the leaves, the shape of the fruits and constituents of the oil, and particularly in its timber. It also has a more erect habit than *E. bicolor*, *E. populifolia* has much wider leaves and a different venation, but the barks of the species are similar. It is usually associated with *E. populifolia*, with the green "Mallee" *E. viridis*, R.T.B., and with the "Grey Mallee" *E. Morrisii*, R.T.B., on which account it is called "Mallee Box." It is never seen as a "Mallee," and as a result of inquiries it appears that it does not grow in that form. The fruits at once differentiate it from *E. albens*, Miq., *E. odorata*, and several other species with which it has been synonymised in recent years.

**ESSENTIAL OIL.**—Leaves and terminal branchlets were obtained for distillation from several localities in the neighbourhood of Girilambone, N.S.W. The oil obtained from leaves from this locality in January, 1900, gave the following results. Yield of oil was 0.5 per cent. The colour of the crude oil was orange-brown, and in odour and constituents resembled that from the typical "Boxes." Pinene was detected, but phellandrene was absent, and this is usually the case with the oils of all the species included in the group of "Boxes." Aromadendral was present in some quantity, and it was to this constituent that the lævo-rotation was chiefly due. Cineol was present, but only about 10 or 12 per cent. in the crude oil. Cymene was detected, this hydrocarbon being evidently a constant constituent in the oils of this group.





R.T.B., del.

**EUCALYPTUS WOOLLSIANA, R.T.B.**  
MALLEE BOX.





On redistilling the crude oil, the results below were obtained. These show it to be in agreement with those of the "Boxes" such as *E. hemiphloia*, &c. The oils of this group have no commercial value at present.

The crude oil had specific gravity at 15° C. = 0.889; rotation  $a_D$  — 12.2°; refractive index at 20° = 1.4838, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 9.1.

On rectification 2 per cent. distilled below 167° C. (corr.). Between 167–183°, 77 per cent. distilled; between 183–224°, 11 per cent. came over, and between 224–265°, 3 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8773; rotation  $a_D$  — 8.3°.

Second " " " = 0.9138; " not taken.

Third " " " = 0.9282; " not taken.

The presence of aromadendral is well demonstrated by the rotation of the crude oil to the left being higher than that of the first fraction. Although light did not pass well with the second fraction, yet it was highly lævo-rotatory.

In order to test the constancy of the oil products from this species, three other consignments were received from various localities in the Girilambone district, and one from Condobolin, also in N.S.W. The oils were all in agreement, as can be seen from the tabulated results. They all formed clear solutions with 1 volume 80 per cent. alcohol.

| <i>E. Woollsiana</i> ,<br>Crude Oils | Specific Gravity<br>at 15° C. | Optical Rotation<br>$a_D$ | Yield of Oil<br>per cent. |
|--------------------------------------|-------------------------------|---------------------------|---------------------------|
| 25th January, 1900 ... ..            | 0.8890                        | — 12.2°                   | 0.50                      |
| 13th March, 1900 ... ..              | 0.8917                        | — 9.5°                    | 0.45                      |
| 16th March, 1900 ... ..              | 0.8947                        | — 15.8°                   | 0.52                      |
| 26th March, 1900 ... ..              | 0.8977                        | — 12.9°                   | 0.52                      |
| Condobolin, 25th March, 1901 ... ..  | 0.9051                        | — 11.9°                   | 0.52                      |

## 120. *Eucalyptus albens*.

(Miq., in Ned. Kruidk. Arch., iv., 138.)

### White Box.

**Systematic.**—Generally a finer tree than its congener *E. hemiphloia*, F.v.M. The barks of both are very similar, being white, but not deeply furrowed. It occurs generally on higher ground than the "Box" *E. hemiphloia*, F.v.M., and the timber is considered the better of the two. Leaves lanceolate, falcate, long and broad, coriaceous, glaucous; the venation is generally prominent, the intramarginal vein is removed from the edge. Peduncles axillary,

sometimes 9 lines long. Buds long and acuminate, apparently sessile, but really tapering into short pedicels, mostly covered with whitish bloom; operculum conical, acuminate, sometimes obtuse, almost as long as the calyx tube.

**Fruit.**—Pedicellate or sessile, obovoid, oblong, truncate, glaucous; rim narrow, the capsule deeply sunk; valves not exerted; about 6 lines long, 3 lines in diameter.

*A very distinct fruit which readily separates it from E. hemiphloia. The glaucousness alone is sufficient to identify the fruit, for it has this feature more pronounced than most others.*



**Habitat.**—Distributed throughout the Central Division of New South Wales; Victoria; South Australia.

**REMARKS.**—Baron von Mueller was inclined to consider this species a variety of *E. hemiphloia*, F.v.M., but in the field the two trees are never confounded. "White Box" has a pale-coloured, hard, close-grained timber, which is highly prized for its durability, whilst the timber of *E. hemiphloia* is often of poor quality. The size and shape of the fruits, and the form of the leaf, differentiate that species from *E. albens* and the fruits at once differentiate this species from *E. Woollsiana*, R.T.B.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Rylstone, N.S.W., in June, 1900. The yield of oil was 0.11 per cent. The crude oil was orange-brown in colour, and had a secondary odour of aromadendral, of which constituent it contained a good quantity; in fact, the resemblance between this oil and those from *E. hemiphloia* and *E. Woollsiana* was most marked. The oil contained a fair quantity of cineol; pinene was present, but phellandrene was absent. Cymene was detected. The influence of the aromadendral is shown by the high lævo-rotation of the third fraction. The oil of this species has no commercial value at present, even if the yield were greater.

The crude oil had specific gravity at 15° C. = 0.9044; rotation  $a_D$  — 6.5°; refractive index at 20° = 1.4679, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 8.5.

On rectification, 2 per cent. distilled below 167° C. (corr.). Between 167–183°, 76 per cent. distilled; between 183–224°, 11 per cent. came over, and between 224–255°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8950; rotation  $a_D$  — 5.6°.

Second " " " = 0.9137; " — 6.1°.

Third " " " = 0.9427; " — 14.4°.

The cineol, determined by the phosphoric acid method in the first fraction, was 37 per cent., indicating about 30 per cent. in the original oil (O.M.).

## 121. *Eucalyptus hemiphloia*.

(F.v.M., Fragm., ii, 62.)

**Box.**

**Systematic.**—This tree is stated by some collectors to reach 150 feet in height, with a corresponding diameter, but we have never found it to exceed 80 to 90 feet, and it is on an average a fair-sized tree; bark persistent, grey, extending to the base of the branches, which are smooth, or with a flaky bark. Leaves ovate-lanceolate, acuminate, sometimes up to 5 or 6 inches in length,





EUCALYPTUS HEMIPHLOIA, F.V.M.  
"Box."





A TYPICAL BOX BARK.

(*Eucalyptus hemiphloia*, F.v.M.)

This is a more compact, ridged bark than any of the other fibrous groups, a light grey in colour and the lattice pattern much smaller than in the "Stringybarks," the furrows moderately deep. The oils of Eucalypts with barks of this character all contain pinene, cineol and the aldehyde aromadendral. Cymene also appears to be a constant constituent, and phellandrene can sometimes be detected.





PLATE LXV



A cross section showing a portion of a rather thin leaf with two oil glands in the field of vision. Several columns of supporting tissue are seen and the few bundles (red) are the veins of the leaf. There is little differentiation between the spongy tissue and palisade parenchyma, whilst the epidermis is thin and composed of irregularly shaped cells.



**EUCALYPTUS HEMIPHLOIA, F.V.M.**





greyish on both sides; veins not prominent, lateral ones oblique, the intra-marginal vein removed from the edge. Flowers mostly in umbels, forming terminal panicles. Calyx tube tapering into a short, angled pedicel; operculum conical, and as long as the calyx tube.

**Fruit.**—Petiolate or sessile, cylindrical or urn-shaped; rim thin; valves quite enclosed; 3 to 4 lines long and 2 lines in diameter.

*The nearest in shape to this fruit is that of E. corynocalyx.*



**Habitat.**—Distributed throughout the whole coastal area, and well into the tableland of New South Wales; South Australia; Victoria; Queensland.

**REMARKS.**—*E. hemiphloia* is the common "Box" of the Coast and Dividing Range, and is distinct from any of the "Box" trees of the interior. The timber is pale-coloured, hard, but not highly valued. This tree can be distinguished from *E. albens* by its smaller fruit and smaller leaves, and an absence of glaucousness on its branchlets, leaves, and buds. The fruits are characteristic, and differentiate it from *E. conica*, H.D. & J.H.M., and *E. Woollsiana*, R.T.B.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Belmore, N.S.W., in September, 1900. The yield of oil was 0.58 per cent. The crude oil was reddish-brown in colour, and had a somewhat rank odour, with a secondary one of aromadendral. It contained some pinene, but phellandrene was absent at this time of the year. Cineol was present, but only about 15 per cent. in the crude oil. Aromadendral occurs in quantity, and it was from this oil that the pure substance was first prepared for research. The esters were not pronounced. Little difference in the constitution of the oils from this species, *E. albens*, and *E. Woollsiana* was observed.

The crude oil had specific gravity at 15° C. = 0.9117; rotation  $a_D$  — 6.85°; refractive index at 20° = 1.4853, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 5.8.

On rectification, 2 per cent. distilled below 168° C. (corr.). Between 168–183°, 73 per cent. distilled; between 183–214°, 13 per cent. came over, and between 214–230°, 6 per cent. distilled. These fractions gave the following results:—

|                             |                             |                        |
|-----------------------------|-----------------------------|------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.9041; | rotation $a_D$ — 3.2°. |
| Second     ,,     ,,     ,, | = 0.9122;                   | ,, — 10.3°.            |
| Third     ,,     ,,     ,,  | = 0.9424;                   | ,, — 24.9°.            |

The cineol, determined by the phosphoric acid method in the first fraction, was 24 per cent., indicating about 18 per cent. in the crude oil (O.M.).

Material had previously been obtained from Emu Plains, N.S.W., in September, 1899; the oil was practically identical with the above. It was, in fact, after the investigation of this sample that it was decided to obtain sufficient oil of this species for the preparation of aromadendral, in order that its chemistry might be determined.

The above samples were mixed together and stored in the dark, and in September, 1919, the oil was again analysed. Not much alteration had taken place in the oil during the nineteen years it had been kept, except that it had perhaps increased a little in cineol. 74 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9166; rotation  $a_D$  — 5.5°; refractive index at 20° = 1.4859.

Rectified portion     ,,     = 0.8933; rotation  $a_D$  — 7.5°; refractive index at 20° = 1.4796.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 31 per cent. Only about 20 per cent. of cineol was present in the fraction as indicated by phosphoric acid, or about 15 per cent. in the crude oil. This result is typical of the oils of the "Box" group, and shows that constituents other than cineol are absorbed by resorcinol.

In March, 1920, fresh material for distillation was collected at Cabramatta, near Sydney. The yield and general characters of the oil were in fair agreement with those previously obtained from this species, with the exception that phellandrene was present at this time of the year, and consequently the lævo-rotation was higher. Cymene was also detected and its chemistry determined, as was also that of the pinene, which was slightly lævo-rotatory. Cineol did not exceed 10 per cent. in the crude oil. A considerable amount of alcoholic bodies was present, as the saponification number after acetylation was 70.5. For the determination of the aromatic aldehydes see the article on "The cyclic (aromatic) aldehydes occurring in Eucalyptus oils."

## 122. *Eucalyptus gracilis*.

(F.v.M., in Trans. Vict. Inst., i., 35, and "Eucalyptographia," Dec., iii, partim.)

### A Mallee.

**Systematic.**—A shrub or small tree with a smooth bark, having several stems from the same root. Leaves lanceolate, generally with a recurved point, under 5 inches long, and  $\frac{1}{4}$  inch wide, thick or coriaceous, drying a light yellowish colour, shining on both sides; venation quite hidden or only traced with difficulty. Peduncles short (3 lines long), flattened, axillary, with not more than half a dozen flowers in the umbel. Calyx tube under 2 lines long, tapering into a short pedicel, angular, 1 line in diameter; operculum hemispherical, shortly acuminate.

**Fruit.**—On slender pedicels, oblong, cylindrical to pyriform; rim not thick, countersunk; valves not exserted; from 2 to 3 lines long, under 2 lines in diameter.



*In size and shape they closely resemble E. polybractea and E. viridis, but are of a yellow tint and not green as obtains in those species.*

**Habitat.**—Districts of the Darling and Murray Rivers, and as far east as Gunbar, New South Wales; South Australia; Victoria; Queensland.

**REMARKS.**—The description given above refers to the "Mallee" occurring in the districts of the Murray and Darling Rivers. A species is figured by Mueller in his "Eucalyptographia" under the above specific name, but in the same plate he gives another figure, which is either *E. viridis*, R.T.B., or a narrow leaf form of *E. Woollsiana*, R.T.B. Mr. Maiden synonymises it under *E. calycogona*, var. *gracilis* Cr. Rev. vol. i, p. 79), but later *loc. cit.* (vol. iv, p. 262), restores it to specific rank.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Gunbar, N.S.W., in December, 1900. The yield of oil was 0.9 per cent. The crude oil was amber-coloured, and had an odour resembling those in which aromadendral is a pronounced constituent. Pinene was present, and this



terpene appears to be dextro-rotatory; phellandrene could not be detected. Cineol was present in small amount; it was determined quantitatively in the second fraction. Aromadendral was present in some quantity in the higher boiling portion, and the occurrence of this aldehyde was also indicated by the rotation figures. Esters were not pronounced, but volatile aldehydes were present in some quantity.

The crude oil had specific gravity at 15° C. = 0.9098; rotation  $a_D + 1.35^\circ$ ; refractive index at 20° = 1.4714, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 6.2.

On rectification, 2 per cent. distilled below 162° C. (corr.). Between 162–172°, 35 per cent. distilled; between 172–204°, 52 per cent. came over, and between 204–235°, 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8939; rotation  $a_D + 6.97^\circ$ .

Second „ „ „ = 0.9096; „ + 0.24°.

Third „ „ „ = 0.9464; „ — 9.94°.

The cineol, determined by the phosphoric acid method in the second fraction, gave a result indicating about 19 per cent. of that constituent in the crude oil (O.M.).

This sample of oil had been stored in the dark, and in August, 1919, was again analysed. From the results now obtained, nineteen years after the oil was distilled, it is evident that little alteration had taken place during all that time, and the constants of specific gravity and optical rotation were practically the same. No deposit had formed in this oil, nor does it occur in any oil belonging to this group. Perhaps the cineol had increased a little in amount. The crude oil and the redistilled portion gave the following results. 86 per cent. distilled below 190° C.:—

Crude oil, sp. gr. at 15° C. = 0.9138; rotation  $a_D + 1.2^\circ$ ; refractive index at 20° = 1.4712.

Rectified portion „ „ = 0.9050; rotation  $a_D + 4.0^\circ$ ; refractive index at 20° = 1.4667.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 47 per cent.

A cineol determination by the phosphoric acid method in the rectified portion gave 35 per cent., representing about 30 per cent. in the crude oil.

## 123. *Eucalyptus viridis*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 316, t. XIX.)

Green Mallee, Red Mallee, Brown Mallee.

**Systematic.**—A “Mallee” of dense growth, the stems usually 2 to 3 inches in diameter, but occasionally measuring 20 feet in height; it rarely grows to tree size; bark smooth, or only rough at the base of the larger trees. Abnormal leaves constantly much narrower than normal leaves. Normal leaves erect, narrow-lanceolate, to almost linear, under 6 inches long, mostly 2 to 4 inches, obtuse or acute, colour rich green, but lustreless on both sides, petiole short; venation obscured, lateral



veins spreading, intramarginal vein not far removed from the edge. Flowers seven to ten, on axillary peduncles. Buds 4 to 6 lines long; calyx tube under 2 lines in diameter, pyriform; operculum hemispherical, very shortly acuminate.

**Fruit.**—Hemispherical to pyriform, on a pedicel of from 1 to 3 lines long; rim thin, contracted at the edge; valves inserted; about 2 to 3 lines in diameter.



*The fruits are very like those of E. polybractea.*

**Habitat.**—On the hills near Girilambone, thence across country to Cobar; also 7 miles out from Coolabah, on the Wilga Downs Road, Wyalong, New South Wales; Victoria (back country).

PLATE LXVI.



*E. VIRIDIS*, R.T.B.  
GREEN MALLEE.

**REMARKS.**—This is a "Mallee" with an extensive range between the Bogan and Lachlan Rivers. The fruits vary little in size, and very often cannot be distinguished from those of *E. Woolfsiana*, R.T.B., a species with a "Box" bark, pale coloured timber, and with variable leaves. It has little botanical connection with *E. gracilis*, and is a very distinct and constant species throughout its geographical distribution. The bark is of a fibrous nature, but not deeply furrowed, and of a peculiar rich yellow colour on the inner side. Mr. Maiden synonymises it under *E. acacioides*, A. Cunningham (Crit. Rev. vol. ii, p. 45), and in a footnote states:—"A. Cunningham discovered this plant first, and first gave it a name . . . . Bearing in mind the haphazard circumstances under which Eucalyptus names were sometimes promulgated in the early days, the name is tenable, and doubtless would have been adopted by Mr. Baker, had he known it. To Mr. Baker belongs the credit of the first description of this species, and, under the circumstances, I am in doubt as to whether the name *viridis* should not be adopted."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Girilambone, N.S.W., in January, 1900. The yield of oil was 1.1 per cent. The crude oil was of a light orange-brown colour, and had an odour indicating the presence of aromadendral. Pinene was present, but phellandrene was absent. Cineol was detected, about 10 per cent. of that constituent being present in the crude oil. Aromadendral was determined in the higher boiling portions, and its presence was also indicated by the left rotation of the crude oil being greater than that of the first fraction. The amount of esters was not large.

The crude oil had specific gravity at 15° C. = 0.9006; rotation  $a_D$  — 8.1°; refractive index at 20° = 1.4771, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 5.7.

On rectification, 2 per cent. distilled below  $167^{\circ}$  C. (corr.). Between  $167-183^{\circ}$ , 78 per cent. distilled; between  $183-234^{\circ}$ , 11 per cent. came over, and between  $234-255^{\circ}$ , 4 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8882; rotation  $a_D - 7.3^{\circ}$ .  
 Second " " " = 0.9148; "  $a_D - 8.5^{\circ}$ .  
 Third " " " = 0.9377; " not taken.

These figures indicate that this "Mallee" is closely associated with the group of typical "Boxes," as *E. hemiphloia*.

This sample of oil had been stored in the dark, and in September, 1919, was again analysed. Some alteration is apparent, such as a diminution in the optical activity, a slight increase in specific gravity, and perhaps a slight increase in cineol. 80 per cent. distilled below  $190^{\circ}$  C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9070; rotation  $a_D - 2.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4769$ .

Rectified portion " = 0.8942; rotation  $a_D - 6.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4699$ .

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 38 per cent. A qualitative determination with phosphoric acid indicated about 10 to 15 per cent. of cineol in the fraction, or about 12 per cent. in the original oil. A considerable amount of constituents, other than cineol, were thus absorbed by the resorcinol, and this result appears to be characteristic with oils of this group.

## 124. *Eucalyptus uncinata*.

(Turcz., in Bull. Mosc., 1849, ii, 23, Syn. *E. leptophylla*, Miq.)

### A Mallee.

**Systematic.**—A tall shrub, with several thin stems, branched from near the base, with a smooth, red, or ashy-grey bark, coming off in thick flakes, branches erect. Leaves narrow-lanceolate, about 3 inches long, under  $\frac{1}{2}$  inch wide, light green in colour, somewhat shining, generally terminated by a short, narrow, hooked apex, from which the specific name is, in this instance, derived, conspicuously black-dotted, especially underneath. Peduncles mostly in the axils of the leaves, each bearing an umbel of about six to eight small flowers; operculum obtusely conical or acuminate, occasionally of a reddish colour.

**Fruit.**—Small, globular, or pear-shaped, more or less shining; rim comparatively broad, sometimes countersunk; valves thin, acuminate, tips just exerted; 2 to 3 lines long and up to 2 lines in diameter.

*E. odorata* and *E. Behriana* more closely match these than any other.

**Habitat.**—Far interior of New South Wales; Western Australia; South Australia; Victoria.





**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were forwarded by Mr. Walter Gill, the Conservator of Forests, South Australia. The material was collected at the Parilla Forest Reserve, of that State, in November, 1919. The yield of oil was 1.4 per cent. The crude oil was of an orange-brown colour, and had an odour indicating those of the "Mallee" oils, allied to the "Box" group. Aromadendral was quite pronounced. The constituents present besides the aromadendral were dextro-rotatory pinene, cymene, cineol, the sesquiterpene, and alcoholic bodies. Phellandrene was absent.

The crude oil had specific gravity at 15 °C. = 0.9111; rotation  $a_D$  — 2.4°; refractive index at 20° = 1.4754, and was soluble in 5 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 13.5; after acetylation, it was 54.5, thus indicating 11.6 per cent. of free alcohols having a  $C_{10}H_{18}O$  molecule.

On rectification, 1 per cent. distilled below 160° C. (corr.). Between 160–172°, 10 per cent. distilled; between 172–192°, 71 per cent. came over, and between 192–260°, 18 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8872; rotation  $a_D$  + 3.5°; refractive index at 20° = 1.4679.

Second " " " " = 0.9023; rotation  $a_D$  — 0.2°; refractive index at 20° = 1.4719.

Third " " " " = 0.9407; rotation  $a_D$  — 10.8°; refractive index at 20° = 1.4909.

The cineol, determined by the resorcinol method in the portion distilling below 192°, and calculated for the original oil, was 40 per cent. By the rapid phosphoric acid method it was 20 per cent., showing the presence of a considerable amount of constituents, other than cineol, absorbed by the resorcinol.

400 c.c. of the crude oil were distilled, and the portion which came over below 188° C. (corr.) separated; this equalled 66 per cent. This portion had specific gravity at 15° = 0.8976; rotation  $a_D$  + 1.2°; refractive index, 1.4706. The saponification number for the esters and free acid was 9.2. After acetylation this was 29, indicating 5.6 per cent. of alcoholic bodies with the  $C_{10}H_{18}O$  molecule. The aldehydic absorption was 5 per cent.

The cineol in this large portion, determined by the resorcinol method, was 45 per cent., and by the phosphoric acid method 35 per cent. This result indicates that bodies other than cineol were absorbed by the resorcinol. No less than 11 per cent. distilled between 188–192°, which portion was evidently largely absorbed.

The aromadendral was separated by acid sodium sulphite from the portion boiling above 188°; when purified it had optical rotation  $a_D$  — 49.8°.

The cymene was determined in the portion distilling below 188° C. The cineol was removed by phosphoric acid, and 50 per cent. resorcinol. The remaining oil was distilled, and the required fraction separated. This had specific gravity at 15° C. = 0.8642; rotation, nil, and refractive index at 20° = 1.4845. A portion was oxidised by potassium permanganate in the usual way. The finally prepared acid melted at 155–156° C., thus indicating p-oxyisopropylbenzoic acid, the oxidation product of p-cymene.



## GROUP VI.

In this group are placed the following EUCALYPTS yielding an oil consisting principally of pinene, cineol, and phellandrene, but in which the cineol does not exceed 40 per cent.

|      |                   |                       |
|------|-------------------|-----------------------|
| 125. | <i>Eucalyptus</i> | <i>viminalis.</i>     |
| 126. | <i>E.</i>         | <i>Gunnii.</i>        |
| 127. | <i>E.</i>         | <i>rubida.</i>        |
| 128. | <i>E.</i>         | <i>Irbyi.</i>         |
| 129. | <i>E.</i>         | <i>Bancrofti.</i>     |
| 130. | <i>E.</i>         | <i>acervula.</i>      |
| 131. | <i>E.</i>         | <i>hæmastoma.</i>     |
| 132. | <i>E.</i>         | <i>Laseroni.</i>      |
| 133. | <i>E.</i>         | <i>ovalifolia.</i>    |
| 134. | <i>E.</i>         | <i>Dawsoni.</i>       |
| 135. | <i>E.</i>         | <i>angophoroides.</i> |
| 136. | <i>E.</i>         | <i>microtheca.</i>    |
| 137. | <i>E.</i>         | <i>fastigata.</i>     |
| 138. | <i>E.</i>         | <i>fraxinoides.</i>   |
| 139. | <i>E.</i>         | <i>macrorhyncha.</i>  |
| 140. | <i>E.</i>         | <i>capitellata.</i>   |
| 141. | <i>E.</i>         | <i>acmenioides.</i>   |
| 142. | <i>E.</i>         | <i>Planchoniana.</i>  |
| 143. | <i>E.</i>         | <i>pilularis</i>      |
| 144. | <i>E.</i>         | <i>obliqua</i>        |
| 145. | <i>E.</i>         | <i>crebra</i>         |
| 146. | <i>E.</i>         | <i>siderophloia</i>   |
| 147. | <i>E.</i>         | <i>melanophloia</i>   |
| 148. | <i>E.</i>         | <i>cærulca</i>        |

## 125. *Eucalyptus viminalis*.

(Labill., in Pl. Nov. Holl., ii, 126, t. 151.)

Manna or White Gum.

**Systematic.**—Sometimes a very large tree, probably the largest of New South Wales Eucalypts. Bark smooth, decorticating in long strips, or rough and dark-coloured. Abnormal leaves sessile, cordate-lanceolate, acuminate. Normal leaves lanceolate, mostly under 6 inches long; venation prominent, lateral veins oblique, spreading. Peduncles axillary, about 2 or 3 lines long, mostly three-flowered. Calyx tube hemispherical; operculum acuminate.

**Fruit.**—Hemispherical, shining, reddish-coloured; rim rounded; valves much expanded and well exerted; 3 lines in diameter.



*The fruits of E. Dalrympleana are very much like those of this species, as also are E. pumila, E. Seeana and E. Bancrofti.*

**Habitat.**—Tablelands of the Great Dividing Range, New South Wales; South Australia; Victoria; Tasmania; Queensland.

**REMARKS.**—This is one of the most widely distributed species of the Genus in Australia, as well as probably the tallest. It is moderately constant, varying only a little in specific characters, whether growing in alluvial flats, basalt (Shoalhaven), or granite (Bathurst). Occasionally the number of flowers in the umbel ranges from three up to seven, but the usual number is three. The insect markings on the bark of *E. viminalis* differ from those of *E. hæmastoma*, as they almost invariably occur in straight, horizontal lines, and not in scribbles as obtains in the latter species. *E. lactea*, R.T.B., has the facies of this tree in the field, so that care is required not to confound them, but the abnormal leaves are ovate or lanceolate, and not sessile as in *E. viminalis*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Cadia, near Orange, N.S.W., in June, 1898. The yield of oil was 0.36 per cent. The crude oil was dark-coloured, and had an odour resembling the cineol-terpene oils generally. Dextro-rotatory pinene was present, and phellandrene also, and the presence of this terpene appears to be characteristic for the oil of this Eucalypt wherever found growing. A rather large amount of the sesquiterpene was also present. Cineol occurs only in fair amount.

The crude oil had specific gravity at 15° C. = 0.9162; rotation not taken; refractive index at 20° = 1.4798, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 7.9.

On rectification, 2 per cent. distilled below  $172^{\circ}$  C. (corr.). Between  $172-183^{\circ}$ , 61 per cent. distilled; between  $183-260^{\circ}$ , 18 per cent. came over, and between  $260-275^{\circ}$ , 15 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.9092; rotation  $a_D + 3.60^{\circ}$ .

Second " " " = 0.9152; " " +  $1.79^{\circ}$ .

Third " " " = 0.9402; " " not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 42 per cent., indicating about 28 per cent. in the crude oil (O.M.).

Material of this species for distillation was obtained from Moss Vale, N.S.W., in March, 1899. In general characters the oil differed but little from that distilled from the *Cadia* material. It contained a little more phellandrene, however, and the cineol was hardly so pronounced, otherwise the differences were slight.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9044; rotation  $a_D + 3.7^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4796, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number was 6.1.

Later, in April, 1912, material for distillation was obtained from Hobart, Tasmania, and consisted of leaves and terminal branchlets, collected as would be done for commercial purposes. The crude oil was of an olive-brown colour, fairly rich in cineol, contained pinene, and a small amount of phellandrene. Phellandrene appears to be a constant constituent in the oil of *E. viminalis*, and helps to distinguish the normal form from those somewhat closely related. A considerable quantity of high-boiling constituents was present, consisting largely of the sesquiterpene, consequently the oil was insoluble in 70 per cent. alcohol. The results obtained with this oil from trees growing in Tasmania, agree closely with those of the oil of *E. viminalis* grown in Australia, thus showing the Tasmanian trees to be identical with those on the mainland. The chemical results thus support botanical indications.

The yield of oil was 0.74 per cent. The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9154; rotation  $a_D + 4.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4707, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 9.5.

On rectification, the usual amount of acid water and volatile aldehydes, for oils of this group, came over below  $167^{\circ}$  C. (corr.). Between  $167-173^{\circ}$ , 22 per cent. distilled; between  $173-194^{\circ}$ , 54 per cent. distilled, and between  $194-269^{\circ}$ , 20 per cent. (the greater portion above  $255^{\circ}$  C.). These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8969; rotation  $a_D + 11.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4622.

Second " " " = 0.9088; rotation  $a_D + 3.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4625.

Third " " " = 0.9308; rotation  $a_D + 4.1^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4928.

The rectified oil was yellowish in tint, resembling in this respect the oils of the members of the "Gum" group of Eucalypts. The cineol was determined by the resorcinol method in the portion boiling below  $194^{\circ}$  C., and when calculated for the crude oil represented 50 per cent. By the phosphoric acid method the result was 41 per cent. in the crude oil.



The Cadia sample was stored in the dark, and in September, 1919, was again analysed. The specific gravity had increased somewhat, as had also the cineol. 78 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9237, rotation not taken; refractive index at 20° = 1.4796.

Rectified portion „ = 0.9130; rotation  $\alpha_D + 3.5^\circ$ ; refractive index at 20° = 1.4616.

The cineol was determined by the resorcinol method in the rectified portion and calculated for the crude oil; the result was 62 per cent. By the rapid phosphoric acid method it was 50 per cent. when calculated for the crude oil.

## 126. *Eucalyptus Gunnii*.

(Hook., f., in Lond. Journ. Bot., iii, 499, 1844).

Cider Gum.

**Systematic.**—A small tree with a smooth bark, foliage glaucous when young. Abnormal leaves cordate-ovate or ovate sessile or with petioles varying much in length, usually opposite, sometimes emarginate or mucronate. Normal leaves lanceolate, under 3 inches long, acuminate or mucronate, sometimes falcate, older leaves shining; venation not prominent, intramarginal vein well removed from the edge, lateral veins few, spreading, fairly oblique. Peduncles usually axillary, 1 to 3 lines long, each with three flowers. Calyx tube turbinate, 2 to 3 lines long, almost sessile; operculum hemispherical, umbonate, much shorter than the tube.

**Fruit.**—Cylindrical-turbinate (Kosciusko), or turbinate (Tasmania), almost sessile, more or less glaucous; rim convex or somewhat countersunk; valves slightly exserted in Tasmanian specimen; 3 to 4 lines long, 3 lines in diameter.

*The Tasmanian form is perhaps nearest in shape to E. acervula, E. paludosa and E. camphora, but larger. The Kosciusko form has its nearest counterpart in E. Irbyi.*



**Habitat.**—High elevations in New South Wales; Victoria; Tasmania.

**REMARKS.**—Hooker's description of this species in his "Flora Tasmaniae," under the common name of "Cider Gum," and his original in the London Journal of Botany, 1844, iii, p. 499, seems to express definitely what species of *Eucalyptus* he had discovered in that Island. However, very much has been written about it in the last few years, especially by Deane and Maiden, and later by Maiden alone, in various scientific publications. Maiden gives in Proc. Linn. Soc., N.S.W., 1902, vol. 26, a long synonymy. Later he describes it in Crit. Rev., vol. iii, p. 106. We deal fully with the history of the species in our paper on the Eucalypts and their Essential Oils, Roy. Soc., Tas., 1912, from which the following short remarks are taken. The name of *E. Gunnii* was bestowed by Sir J. D. Hooker on what is known as the "Cider Tree" of Tasmania, as shown by his own writings and repeated by Bentham, Mueller, Rodway, and others; and this point should be borne in mind when writing on the species.

Whatever tree is now placed under the name it must be a *sine qua non* that it is identical with the "Cider Tree" of Tasmania, for that was the original intention of Hooker. His description accords with that particular tree, and Bentham's reproduction in "Flora Australiensis" (iii, p. 246), equally so, for it accurately describes the material in this Museum obtained from the Tasmanian "Cider Tree," by L. G. Irby, Conservator of Forests, Tasmania, acting under Mr. L. Rodway's direction.

Mr. Irby states in this connection:—"This tree gets its local name from a sweet exudation which flows from it at certain times of the year. This exudation appears to be just the sap of the tree, for by cutting the bark the sweet flavour may be tasted at any time. Where wounded the sap exudes, and crystallises as it flows down the side of the tree. At this time of the year (May) the 'cider' will only flow in small quantities, and cannot be collected. I was informed by local residents that to obtain it in any quantity it is necessary to tap the trees during the spring or summer months. Like manna, this exudation is of a very pleasing flavour, and is rather sought after in consequence. Opossums are extremely fond of it, as also are many birds. I am also informed that at certain times of the year the wattle birds appear to almost live on it."

**ESSENTIAL OIL.**—Material for distillation was collected at Interlaken, Tasmania, in May, 1912. The yield of oil from the leaves and terminal branchlets was 0.39 per cent. The crude oil was dark-coloured, and had a terpene odour, together with that of cineol. The chief constituents in the oil of this species were dextro-rotatory pinene, lævo-rotatory phellandrene, cineol, a sesquiterpene, and a small amount of ester. The dextro-rotation of the higher-boiling portion suggests the presence of the liquid form of eudesmol.

The crude oil had specific gravity at 15° C. = 0.9014; rotation  $\alpha_D + 1.5^\circ$ ; refractive index at 20° = 1.4743, and was soluble in 4 volumes 80 per cent. alcohol.

On rectification, a small amount of acid water and volatile aldehydes came over below 165° C. (corr.). Between 165–173°, 30 per cent. distilled; between 173–198°, 52 per cent.; the thermometer then rose to 254°, and between 254–270° 14 per cent. distilled. These fractions gave the following results:—

|                             |                             |                                   |                                   |
|-----------------------------|-----------------------------|-----------------------------------|-----------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8813; | rotation $\alpha_D + 5.4^\circ$ ; | refractive index at 20° = 1.4671. |
| Second     ,,     ,,     ,, | = 0.8930;                   | rotation $\alpha_D - 4.2^\circ$ ; | refractive index at 20° = 1.4677. |
| Third     ,,     ,,     ,,  | = 0.9377;                   | rotation $\alpha_D + 8.9^\circ$ ; | refractive index at 20° = 1.5004. |

The cineol was determined by the resorcinol method in the oil distilling below 198°, and calculated for the crude oil; the result was 41 per cent. By the rapid phosphoric acid method it was 26 per cent. when calculated for the crude oil.

The saponification number for the esters and free acid was 6.7. The results of this investigation show the oil of this species to be distinct from that of *E. camphora* of New South Wales. *E. Gunnii* has no value as an oil-producing tree; the yield is small, and the main constituents have no special value in the amounts present.

In March and April, 1913, material for distillation was sent by Mr. L. G. Irby from Mount Kosciusko, N.S.W. Two consignments were forwarded, one consisting of mature lanceolate leaves and terminal branchlets only, the other of abnormal leaves only. The idea was to see what differences, if any, were observable in the oils obtained from the two forms of growth.

The results indicate that the oil from the abnormal leaves contains rather more dextro-rotatory pinene than does that from the mature leaves, thus following apparently the general rule in this direction; otherwise the oils were in marked agreement, and the results also in conformity with those of the oil distilled from material of this species from Tasmania, as recorded above. The dextro-rotation of the higher boiling fractions is evidently due to the presence of the liquid form of eudesmol, as no crystals could be detected with either sample. The cineol was more abundant in the Tasmanian oil than in the others, and in slightly larger amount in the mature leaves of the New South Wales material. The



phellandrene was also present in less amount in the abnormal leaves than in the mature. By tabulating the results obtained with the two oils from New South Wales, the differences and agreements are readily shown.

|                                                         | <i>E. Gunnii.</i><br>New South Wales.<br>Mature leaves only. | <i>E. Gunnii.</i><br>New South Wales.<br>Abnormal leaves only. |
|---------------------------------------------------------|--------------------------------------------------------------|----------------------------------------------------------------|
| Yield of oil ... ..                                     | 0.82 per cent.                                               | 0.79 per cent.                                                 |
| Cineol, crude oil ... ..                                | 24 per cent.                                                 | 20 per cent.                                                   |
| Specific gravity, crude oil, at 15° C. ... ..           | 0.8994                                                       | 0.8984                                                         |
| Optical rotation $a_D$ , crude oil ... ..               | -4.3°                                                        | +4.7°                                                          |
| Refractive index at 20°, crude oil ... ..               | 1.4790                                                       | 1.4799                                                         |
| Saponification number ester and free acid, crude oil... | 4.5                                                          | 4.4                                                            |
| Solubility in alcohol, crude oil ... ..                 | 7 vols. 80 per cent.                                         | 8 vols. 80 per cent.                                           |
| Fraction 167-172° C. (corr.) ... ..                     | 19 per cent.                                                 | 26 per cent.                                                   |
| " 172-193° " ... ..                                     | 49 per cent.                                                 | 38 per cent.                                                   |
| " 264-272° " ... ..                                     | 27 per cent.                                                 | 32 per cent.                                                   |
| First fraction—                                         |                                                              |                                                                |
| Specific gravity at 15° C. ... ..                       | 0.8751                                                       | 0.8754                                                         |
| Rotation $a_D$ ... ..                                   | -7.8°                                                        | +2.2°                                                          |
| Ref. index at 20° C. ... ..                             | 1.4669                                                       | 1.4661                                                         |
| Second fraction—                                        |                                                              |                                                                |
| Specific gravity at 15° C. ... ..                       | 0.8816                                                       | 0.8839                                                         |
| Rotation $a_D$ ... ..                                   | -15.1°                                                       | -8.9°                                                          |
| Ref. index at 20° C. ... ..                             | 1.4689                                                       | 1.4676                                                         |
| Third fraction—                                         |                                                              |                                                                |
| Specific gravity at 15° C. ... ..                       | 0.9324                                                       | 0.9257                                                         |
| Rotation $a_D$ ... ..                                   | +2.2°                                                        | +0.9°                                                          |
| Ref. index at 20° C. ... ..                             | 1.5008                                                       | 1.4969                                                         |



## 127. *Eucalyptus rubida*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 456, t. XL.)

### Candle Bark.

**Systematic.**—A tall tree with a smooth bark falling off in ribbons. Abnormal leaves from nearly orbicular to nearly oblong, often emarginate or retuse, opposite, sometimes stem-clasping and even more or less connate, very glaucous in general. Normal leaves dull green on both sides, narrow lanceolate, of thickish texture; the intramarginal vein scarcely removed from the edge, the lateral veins roughly transverse; often glaucous, sometimes very much so. Buds ovoid, axillary, in threes and cruciform, sessile, or with very short stalklets; the stalks commonly under  $\frac{1}{4}$  inch long, round, rarely flattened; operculum nearly hemispherical when ripe, hardly pointed, rather shorter than the calyx, conoid when less ripe.

**Fruit.**—Top-shaped or ovate, spreading at the orifice, sometimes nearly hemispherical, shiny or glaucous; rim broadish and convex; valves three or four, and exserted; usually about 2 to 3 or 3 to 4 lines in diameter.



*It is not unlike some forms of E. Stuartiana, var. lanceolata.*

**Habitat.**—New South Wales, Berrima, to the high tableland of the Monaro from Braidwood to Victoria.

**REMARKS.**—This is the tree that the late Dr. Woolls, in his *Flora of Australia*, confounded with *E. diversicolor*, Desf., owing, no doubt, to the variation in the form of its foliage.

**ESSENTIAL OIL.**—As this species has an extensive range, it was thought desirable to obtain material for distillation from several localities in order to test the constancy of results. Leaves and terminal branchlets were obtained from the following localities in New South Wales:—(1) Bungendore, June, 1898; (2) Bungendore, March, 1899; (3) Wingello, October, 1900; and (4) Cooma, November, 1913. All the material consisted of mature lanceolate leaves. The oil of this species consisted principally of pinene, phellandrene, cineol, and the sesquiterpene. Esters as a rule were not pronounced. Phellandrene was only present in small amount, being rather more abundant in the Cooma material. All the samples were insoluble in 10 volumes 80 per cent. alcohol. The general results obtained with the several oils are recorded in the following table:—

|                        |     | Yield of oil<br>per cent. | Specific gravity<br>at 15° C. | Rotation<br>$\alpha_D$ | Saponification<br>number. | Cineol,<br>per cent. |
|------------------------|-----|---------------------------|-------------------------------|------------------------|---------------------------|----------------------|
| (1) Bungendore, 6/1898 | ... | 0.11                      | 0.9209                        | + 4.4°                 | 6.2                       | 15-20                |
| (2) " 3/1899           | ... | 0.09                      | 0.9137                        | + 2.2°                 | 12.3                      | 15-20                |
| (3) Wingello, 10/1900  | ... | 0.01                      | 0.9067                        | + 3.3°                 | 3.2                       | 10-15                |
| (4) Cooma, 11/1913     | ... | 0.08                      | 0.9180                        | - 1.1°                 | 5.8                       | 10-15                |

## 128. *Eucalyptus Irbyi*, sp. nov.

**Systematic.**—A small tree, with a smooth, pale or ashy-coloured bark. Abnormal leaves broad-ovate to ovate, sometimes mucronate, petiolate, base rounded, truncate or slightly cordate, fairly thick and coriaceous. Normal leaves coarse, lanceolate to broad-lanceolate, or even ovate, acuminate, up to 8 inches long, mostly straight, on unusually long petioles; venation often indistinct, intramarginal vein looped, well removed from the edge, lateral veins spreading, distant, inclined at an angle of 30–40° to the mid-rib. Peduncles angular, axillary, 1 to 2 lines long, bearing umbels of mostly three flowers. Buds shortly pedicellate; calyx tube turbinate, 2 lines in length; operculum blunt, conical, often slightly broader than and more than half as long as the tube.

**Fruit.**—Hemispherical to sub-cylindrical, glaucous, or shining; rim flat to convex, often somewhat depressed, cracked transversely; valves more or less exserted; 3 lines long and 3 lines in diameter.



*Some of the fruits are so like the hemispherical form of E. Gunnii that when the material was first collected it was placed tentatively with that species until other characters could be worked out, but it is, however, a much coarser plant morphologically than that species.*

**Habitat.**—Alma Tier, Interlaken, Tasmania.

**REMARKS.**—Mr. L. G. Irby (Conservator of Forests of Tasmania) was instrumental in first bringing this species forward. He discovered it on the Alma Tier, Interlaken, Tasmania, growing amongst *E. Gunnii*, and thought at first it was *E. viminalis* from the abnormal leaves, but noted its differences in other respects from the normal material of that species collected in other localities in Tasmania during his trip. An exhaustive oil determination, made since publishing our Research on the Eucalypts of Tas., Roy. Soc., 1912, confirmed our suspicion that it was new. In that paper it was placed tentatively under *E. viminalis*. The chief specific differences from this latter are the broader abnormal and normal leaves, both of which are much coarser than those of *E. viminalis*, and are always affected with a fungus, which is never so in *E. Gunnii* or *E. viminalis*, and which gives the whole plant a black, dirty-looking appearance. This is evidently a specific character by which it can be determined, just as in the case of *E. camphora*. The fruits are, however, identical in shape with those of *E. Gunnii*, from which species it differs in the physical features of its bark—lacking the sweet nature of the sap of *E. Gunnii*, which can always be obtained by cutting the bark, and from which it derives its common name of "Cider Gum." In foliage it is not unlike *E. Dalrympleana*, J.H.M. Its affinities lie equally between *E. viminalis* on the one hand, and *E. Gunnii* on the other, so that in a systematic arrangement it might be placed between these two.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained at Interlaken, Tasmania, in August, 1912. The yield of oil was 0.15 per cent., and it contained pinene, phellandrene, cineol, and the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9021; rotation  $a_D$  — 1.7°; refractive index at 20° = 1.4829, and was soluble in 4 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 8.5.

On rectification, 1 per cent. distilled below 167° C. (corr.), and between 167–185°, 66 per cent. distilled. The remainder, which consisted largely of the sesquiterpene, was not distilled.

The rectified oil had specific gravity at 15° C. = 0.886; rotation  $a_D$  + 6.4°; and refractive index at 20° = 1.4760.

The cineol was determined by the phosphoric acid method in the rectified portion; when calculated for the crude oil, the result was 15 per cent.



## 129. *Eucalyptus Bancrofti*.

(J.H.M., in Crit. Rev. Gen. Euc., vol. 4, 14, 1917.)

### Rocky Gum.

**Systematic.**—A medium-sized tree, usually gnarled, bark smooth, falling off in patches. Abnormal leaves ovate-lanceolate, on long, thin petioles. Normal leaves lanceolate to ovate lanceolate, acuminate, sometimes falcate; venation seldom prominent, intramarginal vein fairly close to the edge, lateral veins inclined at an angle of about  $45^\circ$  to mid-rib. Flowers up to seven in umbels, the common peduncle about 4 lines long, axillary. Calyx tube short, about 1 to 2 lines long, somewhat turbinate and contracting shortly to the pedicel; operculum expanded slightly above the top of the calyx tube, egg-shaped, about 3 lines long; an outer operculum first falls off, leaving a line of demarcation at its junction with the calyx tube.

**Fruit.**—Hemispherical; rim broad, almost vertical; valves prominent, much exserted; about 2 to 4 lines long and 3 lines in diameter.



*These fruits are very similar to those of E. Parramattensis, only larger.*

**Habitat.**—Monaro to New England Tableland in the interior, and Camden Haven to Grafton on the Coast, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were collected at Tenterfield, N.S.W., in January, 1910. The yield of oil was 0.5 per cent.

The crude oil was of an orange-brown colour, and had an odour indicating a cineol-pinene oil, with a secondary one somewhat aromatic. The constituents present were lævo-rotatory pinene, phellandrene, cineol, and alcohols. Esters were not very pronounced.

The crude oil had specific gravity at  $15^\circ \text{C.} = 0.8982$ ; rotation  $a_D - 14.4^\circ$ ; refractive index at  $20^\circ = 1.4721$ , and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 12.9; after acetylation it was 41.6, and in the cold with two hours' contact 27.8; the free alcohol calculated for  $\text{C}_{10}\text{H}_{18}\text{O}$  was thus 8 per cent.

On rectification, 1 per cent. distilled below  $166^\circ \text{C.}$  (corr.). Between  $166-172^\circ$ , 10 per cent. distilled; between  $172-178^\circ$ , 36 per cent. distilled; between  $178-193^\circ$ , 38 per cent. came over, and between  $193-277^\circ$ , 12 per cent. distilled. These fractions gave the following results:—

|                                  |                                            |                               |                                           |
|----------------------------------|--------------------------------------------|-------------------------------|-------------------------------------------|
| First fraction,                  | sp. gr. at $15^\circ \text{C.} = 0.8853$ ; | rotation $a_D - 15.8^\circ$ ; | refractive index at $20^\circ = 1.4673$ . |
| Second    ,,        ,,        ,, | $= 0.8877$ ;                               | rotation $a_D - 16.6^\circ$ ; | refractive index at $20^\circ = 1.4685$ . |
| Third     ,,        ,,        ,, | $= 0.8927$ ;                               | rotation $a_D - 15.7^\circ$ ; | refractive index at $20^\circ = 1.4699$ . |
| Fourth   ,,        ,,        ,,  | $= 0.9213$ ;                               | rotation $a_D - 6.0^\circ$ ;  | refractive index at $20^\circ = 1.4870$ . |

The cineol, determined in the crude oil by the rapid phosphoric acid method, was 30 per cent.



## 130. *Eucalyptus acervula*.

(Hook. f., in *Flora Tasmaniae*, 1859.)

Red Gum, White Swamp Gum.

**Systematic.**—A tree about 30 feet in height, with a rough untidy dark-coloured bark; the bark on the branches is smooth and clean. Abnormal leaves ovate or oval, thin, petiolate; venation reticulate, intramarginal vein looped at some distance from the edge. Normal leaves oval to ovate or lanceolate, older leaves thick and shining; venation not prominent, especially in older leaves, intramarginal vein well removed from the edge. Flowers in umbels of about four to eight, peduncles about 4 lines long, sometimes axillary or springing alternately and independently from the stem, giving the inflorescence the appearance of a panicle. Buds about 3 lines long; calyx tube conical, tapering to a very short pedicel, and about twice as long as the blunt conical operculum.

**Fruit.**—Conical, turbinate; rim convex, outer edge sometimes protruding and giving the fruit a bell-shaped appearance; valves occasionally exserted; about 3 lines long and 2 lines broad.



*The nearest in shape to these are E. paludosa and E. camphora, but not E. ovata. Those illustrated are rather larger than generally obtains.*

**Habitat.**—Tasmania (Red Gum) and South Australia (White Swamp Gum).

**REMARKS.**—Morphologically the herbarium material has a resemblance to *E. paludosa*, R.T.B., a mainland species described in 1898 (Proc. Linn. Soc., N.S.W.), and especially are the fruits alike. Maiden (Proc. Linn. Soc., N.S.W., 1901), in a paper on *E. Gunnii*, Hook. f., places both the mainland *E. paludosa*, R.T.B., and the Tasmanian *E. acervula*, Hook. f., under *E. Gunnii*. The results of this investigation show that these three are distinct both botanically and chemically. *E. paludosa*, R.T.B., has a smooth bark, whilst *E. acervula*, Sieb., has mostly a rough bark, and could perhaps on occasions be classified with the *Hemiphloia* group of Eucalypts. "The tree has usually a very bushy top, and the leaves are of rather a pendulous growth" (L. G. Irby), while *E. paludosa* is a fine typical tree, with stout outstretching branches and a straight stem. The abnormal leaves are very different in appearance, shape, and colour from those of *E. Gunnii*, from which species it also differs in the number of flowers in the umbel, bark, timber, and chemical constituents. From our investigations it would appear that the chief differences between *E. acervula*, Hook. f., and *E. paludosa*, R.T.B., are the timber and bark and chemical constituents. *E. acervula* timber is harder, closer grained, and altogether superior to that of *E. paludosa*.

**ESSENTIAL OIL.**—Material for distillation was collected at Hobart, Tasmania, in April, 1912. The yield of oil was 0.2 per cent. The crude oil was reddish in colour, had an odour reminding one of geranyl-acetate, and resembled in some respects the oil of *E. Macarthuri*, of New South Wales. The

chief constituents were dextro-rotatory pinene, lævo-rotatory phellandrene, cineol, geranyl-acetate, free geraniol, together with a small amount of an undetermined alcohol, and its ester, and also a solid paraffin-like stearoptene. A substance of such a character had not previously been recorded for *Eucalyptus* oils; it is not, however, peculiar to this species, for it has already been found in the oils of some New South Wales *Eucalypts*. It most probably belongs to the  $C_nH_{2n+2}$  group, as it is saturated. This solid aliphatic stearoptene is related to a similar substance found in Rose oil, although melting at a higher temperature, and it is remarkable that the principal alcohol in both Rose oil and in the oil of this *Eucalypt* is geraniol. The oil of *E. Macarthuri*, however, does not contain it. Similar paraffins, with varying melting points, have been isolated from the oils of a few other plants, and in some cases from the oils of their leaves. The stearoptene from *E. acervula* is without doubt from the oil of the leaves, because the trees were not in flower at this time of the year.

The oil of *E. acervula* does not agree entirely in general characters with that of *E. paludosa* of New South Wales, as the former contains a small quantity of phellandrene and not much pinene, while the principal terpene in the oil of *E. paludosa* is pinene, and phellandrene appears to be absent. The esters, too, were not identical in composition. They both contained, however, about the same amount of cineol, and the paraffin stearoptene was also found in both, but in much smaller quantity in the oil of *E. paludosa*. The two species may, therefore, be considered as closely related.

The specific gravity of the crude oil at 15° C. = 0.8956; rotation  $a_D$  — 1.1°; refractive index at 20° = 1.4747, and it was soluble in 1 volume 80 per cent. alcohol, but became turbid with 4 volumes, and remained turbid with further addition of alcohol in the cold, forming a flocculent precipitate on standing. On heating the solution it became clear, but the paraffin was deposited again on cooling.

The saponification number for the esters and free acid was 32.8 by boiling, and 21.4 in the cold with two hours' contact; this represents 7.5 per cent. of geranyl-acetate in the crude oil, and 4 per cent. of another ester if calculated for an alcohol having a similar molecular weight. The odour of geraniol in the separated oil, after saponification, was very pronounced, and although the amount of oil at our disposal did not permit of its separation and purification, yet there is no doubt as to its identity, particularly as geraniol and geranyl-acetate are such common constituents in certain classes of *Eucalyptus* oils.

The amount of free geraniol in the oil was considerable, and another undetermined alcohol was also present. A portion of the crude oil was acetylated by boiling with acetic anhydride and anhydrous sodium-acetate in the usual manner; the separated oil was mobile, and had an odour of geranyl-acetate. The saponification number for this esterified oil by boiling was 105.3, and in the cold with two hours' contact, 69.5. This latter figure represents 24.3 per cent. of ester as geranyl-acetate, and indicates that 13.2 per cent. of free geraniol was present in the oil, as well as 6.6 per cent. of another alcohol, assumed to have the same molecular weight.

It is worthy of notice that over 50 years ago, when this species was described by Hooker in his "*Flora Tasmaniae*," he remarked that "The bruised foliage has a much sweeter odour than is usual in the Genus." The discovery of geraniol and its ester in the oil not only confirms this remark, but also indicates the constant character of the chemical constituents.

The acid in the original ester was separated and found to be almost entirely acetic.



On rectification, a little acid water and rather a larger amount of objectionable smelling volatile aldehydes came over below  $175^{\circ}\text{C.}$  (corr.). Between  $175\text{--}200^{\circ}$ , 42 per cent. distilled; between  $200\text{--}228^{\circ}$ , 8 per cent. came over; the thermometer then quickly rose to  $255^{\circ}$ , and between that temperature and  $285^{\circ}$ , 36 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}\text{C.} = 0.8796$ ; rotation  $a_D - 2.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4650$ .

Second „ „ „ „ =  $0.8913$ ; rotation  $a_D - 1.2^{\circ}$ ; refractive index at  $20^{\circ} = 1.4679$ .

Third „ „ „ „ =  $0.9007$ ; rotation  $a_D + 4.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4875$ .

The residue, when poured from the still, became solid when cold; it was boiled in alcohol and the alcohol separated while hot; on cooling, a crystalline paraffin-like substance separated.

To prove the presence of pinene, another 100 c.c. of the oil were distilled, the added two fractions gave 32 c.c. distilling below  $170^{\circ}\text{C.}$  (corr.); it was again distilled, when 15 c.c. was obtained below  $162^{\circ}$ . This contained some cineol, which was removed by shaking with 50 per cent. resorcinol. The remaining 9 c.c. of oil had a pinene odour; specific gravity at  $15^{\circ}\text{C.} = 0.8594$ ; rotation  $a_D + 10^{\circ}$ ; and refractive index at  $20^{\circ} = 1.4690$ . A small quantity of phellandrene was still present, but this did not interfere with the formation of the nitrosochloride; which when purified, melted at the correct temperature for the pinene compound.

The cineol was determined by the resorcinol method in the portion of oil distilling below  $195^{\circ}\text{C.}$ ; the result indicated that 21 per cent. was present in the crude oil. The high-boiling constituent was most probably the sesquiterpene.

Material of this species was also obtained at Little Swanport, Tasmania, in June, 1908. The oil was practically identical with that of the above sample, with the exception that a little more pinene was present at this time of the year. The specific gravity at  $15^{\circ}\text{C.} = 0.898$ , and the refractive index at  $20^{\circ} = 1.4724$ . The saponification number for ester and free acid was 34.3, and the ester consisted mostly of geranyl-acetate. The oil contained the paraffin-like substance in slightly larger amount than did the Hobart sample.

The investigation of the oil of this species was published by us in the Proceedings of the Royal Society of Tasmania, in October, 1912.

In September, 1916, we received material of this species for distillation from South Australia, through the kindness of Mr. Walter Gill, the Conservator of Forests of that State.

The oil was practically identical with that previously distilled from this species growing in Tasmania. This was particularly noticeable through the esters and the solid paraffin, although it contained more of the sesquiterpene.

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.930$ ; rotation  $a_D - 1.4^{\circ}$ ; refractive index at  $20^{\circ} = 1.4870$ , and was soluble in 1 volume 80 per cent. alcohol, but with excess precipitated the paraffin.

Geranyl-acetate was present to the extent of 14 per cent., as the saponification number, in the cold with two hours' contact, was 40.7.



## 131. *Eucalyptus hæmastoma*.

(Sm., in Trans. Linn. Soc., iii, 285.)

White or Scribbly Gum.

**Systematic.**—A medium-sized tree, having a white, smooth bark, almost invariably showing insect markings, similar to a "Scribble," hence the vernacular name. Branchlets quadrangular. Abnormal leaves variable, either ovate-lanceolate, shortly acuminate, with the venation scarcely discernible, about 4 inches long, or falcate-lanceolate, measuring 9 inches in some instances, and venation also faint. Normal leaves lanceolate, falcate, acuminate, variable in size, of a pale-green colour, shining, coriaceous; venation indistinct, lateral veins oblique, spreading, intramarginal vein removed from the edge. Flowers on flattened axillary peduncles about 1 inch long, six or more in the umbel; buds clavate; calyx tube about 2 lines in diameter, tapering into a pedicel of about 2 to 3 lines long.

**Fruit.**—Pedicellate, hemispherical or pear-shaped, shining; rim thick, convex, red-coloured; valves sunk; up to 5 lines in diameter.

*These fruits present no difficulty in determination, the red rim and shining sides readily identify them. They very closely resemble E. vitrea. The fruits, however, vary in size and when small are known as var. micrantha, Syn. E. micrantha, DC.*



**Habitat.**—Sydney, Gosford, Richmond River, Cooma, Blue Mountains, New South Wales; Tasmania; Victoria; Queensland.

**REMARKS.**—The *Eucalyptus* here designated is the one with the whitish bark, having "Scribbles" (insect markings) upon it. The timber is of a pinkish colour, and of little commercial value. It has comparatively large fruits and coriaceous leaves. The individual species synonymised in the past under *E. hæmastoma* will, no doubt, all be shown on a natural classification to be quite distinct, and the "Spotted Gum" has been proved worthy of specific rank under the name of *E. maculosa*, R.T.B., also the "Stringybark" variety of Mueller and Woolls is now *E. Wilkinsoniana*, R.T.B. De Candolle's species, *E. micrantha*, had been placed by Mueller as a variety of this *Eucalyptus*, with which we concur. The coarse, thick leaves, and larger fruits and flowers distinguish Smith's *E. hæmastoma* from *E. Rossii*. Baron von Mueller's figure of *E. hæmastoma*, in his "Eucalyptographia," faithfully depicts the species, which derives its specific appellation from the red rim of its fruits—a character, however, that occurs in several other species of *Eucalypts*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, N.S.W., in June, 1898. The yield of oil was 0.28 per cent. The crude oil was of a red colour, had a terpene odour, and was somewhat viscous. A large amount of phellandrene was present in the first fraction, which also contained about 10 to 15 per cent. of cineol. The third fraction consisted largely of the liquid form of eudesmol and the sesquiterpene, more than half the oil distilling above 245° C. It was to the presence of these constituents that the somewhat viscous nature of the oil was due. The peppermint constituent, piperitone, was not detected, nor did aromadendral appear to be present.

The crude oil had specific gravity at 15° C. = 0.9195; refractive index at 20° = 1.4955, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 5.1; after acetylation it was 55.6, corresponding to 20.8 per cent. if calculated for a sesquiterpene alcohol.

On rectification, 1 per cent. distilled below  $174^{\circ}$  C. (corr.). Between  $174-193^{\circ}$ , 25 per cent. distilled; between  $193-245^{\circ}$ , 14 per cent. came over, and between  $245-283^{\circ}$ , 55 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8728; rotation  $a_D - 28.6^{\circ}$ .

Second „ „ „ = 0.8816; „ —  $20.4^{\circ}$ .

Third „ „ „ = 0.9417; „ not taken.

A second distillation gave agreeing results, and on again fractionating the combined higher-boiling portions, only 5 per cent. came over below  $260^{\circ}$  C.; between  $260-275^{\circ}$ , 68 per cent. distilled; this portion had specific gravity at  $15^{\circ}$  C. = 0.943; and optical rotation  $a_D - 0.8^{\circ}$ . (See also the article dealing with the sesquiterpene in this work.)

Material of this species was also obtained from Gosford, N.S.W., in December, 1896. In appearance and constituents, this oil differed but little from the Barber's Creek sample, with the exception that pinene was a little more pronounced and the phellandrene correspondingly less; the amount of cineol was about the same as in the previous sample. 50 per cent. distilled between  $255-280^{\circ}$  C.; and this fraction also consisted principally of eudesmol and the sesquiterpene. The ester content was practically the same as in the oil from Barber's Creek.

Material of this species for distillation was received from Lawson, Blue Mountains, N.S.W., in September, 1919. The yield of oil was 0.65 per cent. In general characters and constituents, the oil differed but little from that distilled in 1898. The exception was that the eudesmol at this time was in the crystallised condition, while in the oil from the Barber's Creek trees it was in the liquid form.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.9065; rotation  $a_D - 5.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4902, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters was 4.4, both by the hot and cold methods. After acetylation it was 86.6 by boiling, and 23.7 in the cold, with two hours' contact. This result represents 5.4 per cent. calculated as free geraniol, and 26 per cent. calculated as eudesmol. The eudesmol was purified, when it had melting point  $79-80^{\circ}$ , and specific rotation  $[a]_D + 38.43^{\circ}$ .

The cineol was determined by the resorcinol method in the portion boiling below  $193^{\circ}$ ; when calculated for the crude oil the result was 9 per cent.

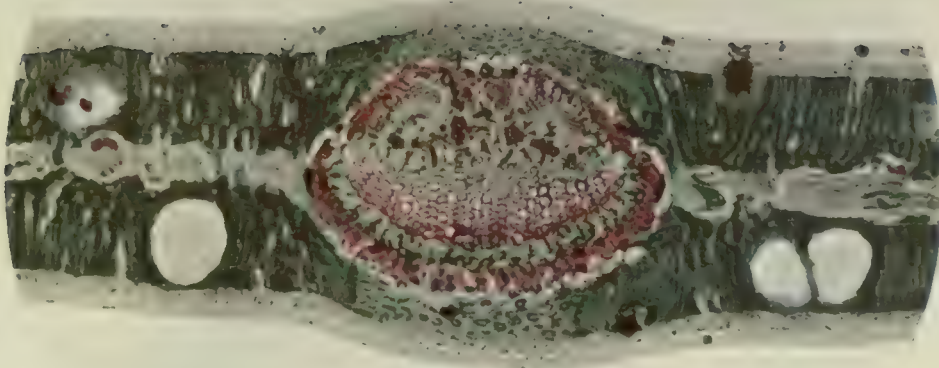
The predominance of phellandrene is seen from the rotation figures for the crude oil. Piperitone was not detected.

## 132. *Eucalyptus Laseroni*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1912, p. 585.)

**Systematic.**—A small tree, under 40 feet in height, 1 foot in diameter, with a hard stringybark, decorticating in strips from the main branches, which are otherwise smooth. Abnormal leaves ovate-lanceolate, slightly falcate in some cases, petiolate, attenuate, varying in size. Normal leaves lanceolate, alternate, sub-coriaceous, average under 4 inches long and 1 inch wide, occasionally shining; venation distinctly marked (the basal lateral veins sometimes running the whole





Leaf of  
*Eucalyptus*

A cross section cut through the mid-rib and adjacent tissue showing the characteristic structure of this coriaceous leaf, which feature carries with it in this instance four rows of parenchyma on both sides of a narrow band of spongy tissue, and an epidermis particularly well pronounced. The wood fibres in two or more rows entirely surround the bundle, which is bounded on both sides by a narrow band of supporting tissue. The yield of oil is only 0.44 per cent., consequently the oil glands are few in number, comparatively, in relation to the thickness of the leaf. This feature is well shown by comparing the plate with *E. Australiana* (Plate L), both sections having approximately the same magnification. x 75

*EUCALYPTUS HÆMASTOMA. SM*





length of the leaf, other lateral veins more transverse. Buds in clusters on axillary peduncles 3 lines long; calyx tube almost sessile, 2 lines long; operculum shortly conical.

**Fruit.**—Hemispherical, capitate, pedicel up to 2 lines long; rim domed; valves scarcely or not exerted; 3 lines broad and 3 lines long.



*These have a strong resemblance to those of E. dives in being shiny, yellow in colour, but the rim is slightly more domed, or a small form (not illustrated) of E. capitellata, but pedicellate.*

**Habitat.**—Black Mountain, Armidale, Barber's Creek, New South Wales.

**REMARKS.**—A tree of rather rare occurrence, being only known so far from two localities (supra). The buds and leaves closely resemble those of *E. stellulata*, but the bark is stringy. The venation belongs to the same class as that of *E. dives* and *E. stellulata* or *E. phlebophylla*.

**ESSENTIAL OIL.**—Material for distillation was received from Black Mountain, New England District, N.S.W., in August, 1907. The yield of oil was 0.37 per cent. The crude oil was dark-coloured and had a terpene-like odour. The constituents present were lævo-rotatory pinene, phellandrene, cineol, esters, and the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9095; rotation  $a_D$  — 8.1°; refractive index at 20° = 1.4790, and was soluble in 6 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 13.4.

On rectification, 2 per cent. distilled below 157° C. (corr.). Between 157–175°, 54 per cent. distilled; between 175–225°, 7 per cent. came over, and between 225–270°, 32 per cent. distilled, the greater portion above 260°. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8705; rotation  $a_D$  — 15.9°; refractive index at 20° = 1.4653.

Second „ „ „ = 0.9006; rotation  $a_D$  — 13.6°; refractive index at 20° = 1.4713.

Third „ „ „ = 0.9428; rotation too dark; refractive index at 20° = 1.4958.

The first fraction was again distilled, when 36 per cent. came over below 157° C., and 38 per cent. between 157–160°. These two fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8665; rotation  $a_D$  — 19.1°; refractive index at 20° = 1.4640.

Second „ „ „ = 0.8693; rotation  $a_D$  — 17.4°; refractive index at 20° = 1.4647.

The nitrosochloride was easily prepared with the first fraction, and this melted at 104° C. It is thus evident that the principal constituent is pinene. Cineol was present, but not more than 5 to 8 per cent. Phellandrene occurs only in small quantity.

The above characters distinguish the oil of this species from that of *E. stellulata*.

### 133. *Eucalyptus ovalifolia*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 680, t. XLVI, figs. 6a, 6b.)

**Systematic.**—A medium-sized tree, with a smooth bark, decortivating at the base of the trunk, producing a roughish appearance. Leaves small, of light yellowish colour, sometimes glaucous, oval, or ovate, shortly acuminate, mostly 2 inches long and  $\frac{3}{4}$  inch wide, rarely 3 inches long, petiole slender, under 1 inch long; venation faintly marked, lateral veins distinct, oblique, spreading, the intra-marginal vein removed from the edge, producing at the base of the leaf a trinerved appearance. Flowers in axillary or terminal panicles, six to eight in the head. Calyx tube under 2 lines long, 1 line in diameter, tapering into a slender pedicel; operculum hemispherical, depressed, very shortly acuminate.

**Fruit.**—Small on slender pedicels, or occasionally almost sessile, contracted slightly at the orifice; rim thin; valves not exerted; 2 lines long and  $1\frac{1}{2}$  lines in diameter.



*Not at all unlike those of E. crebra, E. polybractea, or a smaller form of E. cærulea.*

**Habitat.**—Bathurst, Rylstone, Camboon, Hargraves, Gerozery, N.S.W.

**REMARKS.**—A medium-sized or rather stunted tree, growing in poor, sandy or rocky soil (Devonian). The bark is smooth, except occasionally a foot or two from the ground, where it is rough, something like a "Box" bark. It is allied to *E. melliodora* in the shape and venation of the leaves, and, perhaps, in the exterior character of the bark, but has not the yellow stain on the inner surface such as obtains in *E. melliodora*. It differs, however, from that species in the shape of the fruits, colour of timber, and chemical constituents of its oil. The typical *E. polyanthemos*, Sch., of Victoria, has a persistent "Box" bark, larger and more acuminate, orbicular shaped leaves and larger fruits. The oils of the two species are not at all identical; however, there is a resemblance in their timbers. It is an entirely different species from *E. Dawsoni* or *E. polyanthemos*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Henbury, Rylstone, N.S.W., in December, 1918. The yield of oil was 0.27 per cent. The colour of the crude oil was a light orange-brown, and the odour quite rank and unpleasant. Much phellandrene was present, but pinene only detected in small quantity; a fairly large amount of the sesquiterpene was found. The esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.9058; rotation  $a_D$  — 8.9°; refractive index at 20° = 1.4864, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 6.2.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–188°, 62 per cent. distilled; between 188–256°, 15 per cent. came over, and between 256–270°, 15 per cent. distilled. The third fraction consisted largely of the sesquiterpene. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8925; rotation  $a_D$  — 14.1°.

Second " " " = 0.9046; " not taken.

Third " " " = 0.9305; " not taken.

The oil of this species has little resemblance to that of *E. polyanthemos*, but corresponded to that of the "Lignum-vitæ" of St. Mary's (*E. Fletcheri*), the oils of both species containing similar constituents in practically the same amounts. At the time of distillation, the oil of *E. ovalifolia* contained a very small quantity of cineol, but after keeping for eighteen months it was found to contain about 15 per cent. of that constituent.



## 134. *Eucalyptus Dawsoni*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1899, p. 294, t. XXI.)

Slaty Gum.

**Systematic.**—A tall tree, with a smooth bark. The foliage, branchlets, buds, and fruits, glaucous. Abnormal leaves broadly lanceolate, 6 inches long, and over 3 inches wide, on a petiole over 1 inch long, very obtuse, glaucous on both sides; venation distinct. Normal leaves mostly short, oblong-lanceolate, very obtuse, rarely acuminate, occasionally reddish in colour; venation fairly distinct, lateral veins not quite so marked, intramarginal vein close to the edge. Peduncles axillary, but mostly in large terminal corymbs, exceeding the leaves. Buds on young trees, 3 lines long,  $1\frac{1}{2}$  lines in diameter, sessile or on short pedicels; operculum hemispherical, obtuse; on mature trees, 4 to 5 lines long, 1 line in diameter; calyx tube tapering into a filiform pedicel; operculum conical, acute.

**Fruit.**—Small, on a slender or almost filiform pedicel, turbinate; rim thin, capsule sunk; valves not exerted; mostly 1 line in diameter and under 2 lines long.



*In shape they are not unlike E. crebra, but are always glaucous.*

**Habitat.**—Murrumbidgee, Goulburn River, and northward, Jerry's Plains and Singleton, and Mountains west of Wentworth, New South Wales.

**REMARKS.**—This is a well-marked species, and in the field could never be confounded with any other *Eucalyptus*. The fruits resemble those of the narrow-leaved "Ironbark," *E. crebra*, and the leaves of those of *E. ovalifolia*, the Rylstone "Red Box," but it differs from them in every other specific character. The late Dr. Woolls was very emphatic that this tree should be regarded as quite distinct from *E. polyanthemos*, with which species it had previously been confused. *E. polyanthemos* has a "Box" bark and other characters which are sufficient to differentiate it from *E. Dawsoni*. It is also distinct from *E. ovalifolia*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Bylong, N.S.W., in October, 1898. The yield of oil was 0.18 per cent. The crude oil was of an orange-brown colour, and notably of a viscous nature. This viscosity was due to the presence of an extra amount of the sesquiterpene and higher-boiling bodies. The oil oxidised somewhat readily on exposure, drying much in the same way as does boiled linseed oil. The first fraction consisted largely of phellandrene, but only a very small quantity of cineol could be detected. Esters were not very pronounced, so that the oil was largely a terpene one, although a considerable amount of liquid eudesmol was present.

The crude oil had specific gravity at 15° C. = 0.9418; refractive index at 20° = 1.5077, and was soluble in 2 volumes 80 per cent. alcohol. The light did not pass well. The saponification number for the esters and free acid was 13.3.

On rectification, 1 per cent. distilled below 172° C. (corr.). Between 172–204°, 32 per cent. distilled; between 204–255°, only a few drops came over, and between 255–275°, 38 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8697; rotation  $\alpha_D$  — 23.5°.  
Second " " " = 0.9458; " not taken.

This sample of oil had been stored in the dark, and in September, 1919, twenty-one years after, was again analysed. The lævo-rotation of the lower boiling portion had diminished considerably, and the specific gravity had increased a little, otherwise not much alteration had taken place during this long period. 20 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9553; rotation not taken; refractive index at 20° = 1.5079.

Rectified portion „ „ = 0.8901; rotation  $\alpha_D$  — 4.0°; refractive index at 20° = 1.4805.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 5 per cent.

### 135. *Eucalyptus angophoroides*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1901, p. 676.)

Apple-top Box.

**Systematic.**—A medium-sized tree, with a white box bark, persistent to the ultimate branchlets. Abnormal leaves ovate-acuminate, cordate, shortly petiole, glaucous, variable in size from 1 to 3 or 4 inches long, and 1 to 3 inches broad; venation indistinct on both sides. Normal leaves narrow-lanceolate, about 6 inches long, acuminate, not shining, of the same colour on both sides; venation finely marked, oblique, spreading, intramarginal vein removed from the edge. Peduncles axillary, 3 to 4 lines long, slightly compressed, bearing a few flowers. Calyx tube hemispherical to pyriform, 1 line long, on a pedicel of equal length; operculum hemispherical, shortly acuminate.

**Fruit.**—Shortly pedicellate, hemispherical to slightly pear-shaped; rim thick, convex, having a groove below the edge; valves generally four, exserted, under 1 line long; 2 lines in diameter and 2 to 3 lines long.



*The fruits are much like a small E. viminalis or E. Bridgesiana, but are quite different from those of E. Stuartiana, which have a sloping rim.*

**Habitat.**—Colombo, Towrang, New South Wales.

**REMARKS.**—The herbarium material of this species is so similar to that of *E. Bridgesiana* that on a first examination it might be included with that species. Field observations, however, have shown that the two trees are quite distinct and should not be included under the same name. *E. Bridgesiana* is known vernacularly as "Apple" and "Woollybutt," but this tree as "Apple-top Box." The bark is that of a true "Box," but the timber is quite unlike that of a "Box." The bark has not an essential oil as obtains in *E. Bridgesiana*. Although it has a regular light-coloured grey "Box" bark, yet the appearance of the foliage in the field is more like that of an "Apple-tree" (*Angophora*), hence the local name of "Apple-top Box."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Towrang, N.S.W., in October, 1900. The yield of oil was 0.19 per cent. The crude oil was red in colour, and contained rather a large amount of phellandrene, to which constituent the lævo-rotation of the oil was due. Pinene was determined, and also cineol. It also contained a somewhat large amount



of sesquiterpene. The constituents in the oil of this *Eucalypt* differ greatly from those in the oil of *E. Bridgesiana*, as can be seen by referring to that species.

The crude oil had specific gravity at 15° C. = 0.9049; rotation  $a_D$  — 11.5°; refractive index at 20° = 1.4824, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 7.3.

On rectification, 1 per cent. distilled below 165° C. (corr.). Between 165–183°, 70 per cent. distilled; between 183–245°, 2 per cent. came over, and between 245–270°, 20 per cent. distilled. The third fraction consisted largely of the sesquiterpene. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8886; rotation  $a_D$  — 21.1°.

Third " " " = 0.9392; " not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 26 per cent., indicating about 18 per cent. in the crude oil (O.M.)

This sample was stored in the dark, and in December, 1919, was again analysed. The oil had altered somewhat during the nineteen years it had been kept, and the phellandrene had suffered considerable loss in optical activity; it had otherwise changed, so that only 52 per cent. distilled below 190° C. There was apparently no increase in the amount of cineol. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.9251; rotation  $a_D$  — 2°; refractive index at 20° = 1.4825.

Rectified portion " " = 0.8947; rotation  $a_D$  — 6.4°; refractive index at 20° = 1.4678.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 27 per cent.

## 136. *Eucalyptus microtheca*.

(F.v.M., in Journ. Linn. Soc., iii, 87.)

Coolabah or Tagoon.

**Systematic.**—A tree attaining a height of 80 feet, and a stem diameter of 4 feet (H. K. Bennett). Bark rough, more or less dark or ashy-grey outside, sometimes persistent, but occasionally smooth (F.v.M.). Leaves lanceolate, falcate, *always drying a light slate colour*, oblique, measuring sometimes up to 8 or 9 inches in length and  $\frac{3}{4}$  inch in width, on a petiole of 1 inch or  $1\frac{1}{2}$  inch long; venation fairly prominent, intramarginal one not far removed from the edge. Flowers mostly in terminal panicles. Calyx tube small, almost hemispherical; operculum conical, acuminate.

**Fruit.**—Small, hemispherical, on a slender pedicel; rim thin; valves expanded and much exerted and convex; under 2 lines in diameter.

*These fruits stand alone as regards their shape.*

**Habitat.**—From Narrabri to the deserts of the north-west of New South Wales; South Australia; Queensland; North Australia,



**REMARKS.**—Bentham (B. Fl., iii, p. 223) placed this species under *E. brachypoda*, Turcz., a Western Australian *Eucalyptus*, but Mueller, in his *Eucalyptographia*, restores it to specific rank, mentioning that Drummond's specimens, upon which Bentham worked, were without fruits. The species is a good one, and the tree has an extensive range over the interior, where it is one of the largest of the Genus. It is rough barked, the ulterior branches being smooth; the timber is reddish in colour, hard, and durable. It is chiefly characterised by its small hemispherical fruits, with prominently protruding valves. It is known by several vernacular names throughout its geographical distribution, besides the above, such as "Swamp Box," "Goborro," &c.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Narrabri, N.S.W., in April, 1902. The yield of oil was 0.48 per cent. The crude oil was reddish in colour, and had an odour reminding strongly of cymene. A considerable quantity of phellandrene was present in the oil, and pinene was also determined. Cineol was present only in small amount, hardly exceeding 5 per cent. in the crude oil. Aldehydes were not detected in the higher boiling portions, but those usually found were present in the lower. When the oil of the third fraction was diffused, a distinct cinnamon odour was detected; this has been noticed in several *Eucalyptus* oils. The higher boiling portion consisted largely of the sesquiterpene. Free alcoholic bodies were also present.

The crude oil had specific gravity at 15° C. = 0.8855; rotation  $a_D - 27.2^\circ$ ; refractive index at 20° = 1.4838, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.3.

On rectification, 1 per cent. distilled below 156° C. (corr.). Between 156–172°, 52 per cent. distilled; between 172–224°, 27 per cent. came over, and between 224–274°, 16 per cent. distilled. These fractions gave the following results:—

|                                                                           |
|---------------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. = 0.8645; rotation $a_D - 34.2^\circ$ . |
| Second " " " = 0.8659; " " $- 37.1^\circ$ .                               |
| Third " " " = 0.9338; " " $- 2.8^\circ$ .                                 |

The third fraction was acetylated; the saponification number had then risen to 38.5, showing the presence of alcoholic bodies in this portion. The alcohol was probably the non-crystallised form of eudesmol, particularly as the crystalline body had not been detected at any time.

This sample of oil had been stored in the dark, and in October, 1919, was again analysed. Very little alteration was observed, except that the specific gravity had increased a little, and the rotation diminished about half. The cineol had not increased. 67 per cent. distilled below 190° C.

The crude oil had sp. gr. at 15° C. = 0.9089; rotation  $a_D - 12.2^\circ$ ; refractive index at 20° = 1.4894.

The rectified portion " " = 0.8723; rotation  $a_D - 21.7^\circ$ ; refractive index at 20° = 1.4754.

The cineol, determined by the resorcinol method, was 5 per cent. when calculated for the crude oil.

That the higher-boiling portion consisted largely of the sesquiterpene is shown by the results obtained on distillation at 10 millimetres pressure. The principal fraction boiled at 130–135° C.; had specific gravity at 15° = 0.932; rotation  $a_D + 2.5^\circ$ ; refractive index at 20° = 1.5052, and saponification number after acetylation = 28.5.

## 137. *Eucalyptus fastigata*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1895, p. 798.)

Blackbutt, Peppermint, Cut Tail.

**Systematic.**—A tall tree, the bark of which resembles closely that of *E. obliqua*, the principal difference between the two trees in this respect consisting in the fact that the tops and branches of "Cut-tail" are smooth, while those of *E. obliqua* are the reverse. Abnormal leaves, ovate-lanceolate; the veining of the underside prominent; the twigs rusty, tuberculate, like *E. amygdalina*, and some other species. Normal leaves lanceolate, and, when fully grown, narrow-lanceolate, often more or less ovate-lanceolate, and always more or less attenuate. They are rather chartaceous, smooth, and shining. The chief characteristic of the buds is the shortly acuminate operculum, which is much accentuated in dried specimens.

**Fruit.**—Pear-shaped on a slender pedicel; rim domed; valves somewhat exserted, three-celled, as far as seen; diameter  $2\frac{1}{2}$  to nearly 3 lines.



*This is a very characteristic fruit and when known easily distinguished from the other species. The fruits may be said to somewhat resemble those of E. dives, Schau.; otherwise the species presents no difficulties in determination. It is in no way allied with E. vitrea, R.T.B. It differs from that of E. obliqua in being more or less conical, while that of E. obliqua is sub-cylindrical. E. regnans has a truncate or countersunk rim.*

**Habitat.**—Clyde district, New South Wales; Victoria.

**REMARKS.**—The authors of this species are inclined to regard it as not specifically different from *E. regnans*, of Mueller (Proc. Linn. Soc., N.S.W., 1899, p. 460). We, however, prefer to consider these two Eucalypts as distinct, for Mueller's description of the latter species in Report Acclm. Soc., Vict., No. 1870, is so very clear and precise that he could hardly have confounded the material of *E. fastigata* when describing *E. regnans*. The tree is tall, with a fibrous bark, and has an exceedingly fissile timber, which is in much request locally, and is reputed to be very durable in the ground. It does not occur in Tasmania, where *E. regnans* is to be found, and which has there a smooth bark as well as in Victoria.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, N.S.W., in September, 1898. The yield of oil was 0.12 per cent. The crude oil was red in colour, and had rather an unpleasant odour. It consisted principally of pinene, phellandrene, cineol, and crystallised eudesmol. That the pinene was dextro-rotatory is indicated by the first fraction having a rotation to the right, while the second fraction, which contained most of the phellandrene, was lævo-rotatory. Cineol was present in small amount, about 8 or 10 per cent. in the crude oil. Eudesmol was present in quantity in the third fraction, the oil crystallising solid in the receiver soon after distillation.

The crude oil had specific gravity at 15° C. = 0.9001; refractive index at 20° = 1.4816, and was soluble in 5 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 14.9.



On rectification, 2 per cent. distilled below  $161^{\circ}$  C. (corr.). Between  $161-172^{\circ}$ , 42 per cent. distilled; between  $172-233^{\circ}$ , 20 per cent. came over, and between  $233-286^{\circ}$ , 22 per cent. distilled. These fractions gave the following results:—

|                                            |           |                                |
|--------------------------------------------|-----------|--------------------------------|
| First fraction, sp. gr. at $15^{\circ}$ C. | = 0.8621; | rotation $a_D + 2.8^{\circ}$ . |
| Second     "     "     "                   | = 0.8761; | "     "     — $10.9^{\circ}$ . |
| Third     "     "     "                    | = 0.9536; | "     "     not taken.         |

Material for distillation was also obtained from Delegate Mountain, N.S.W., in February, 1899. The oil was in agreement with the above in colour, odour, and constituents; consisting largely of pinene, phellandrene, and sesquiterpene, with some eudesmol. The excess of phellandrene over the pinene at this time of the year, caused the oil to have a higher lævo-rotation, and it had, perhaps, a corresponding decrease in cineol. The eudesmol was present in about the same amount as in the oil from Monga, the fraction crystallising solid soon after distillation. There was but little difference in the two oils, either in distillation figures or in other characters, beyond the increase in phellandrene.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.8925; and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number was 12.4.

|                                            |           |                                |
|--------------------------------------------|-----------|--------------------------------|
| First fraction, sp. gr. at $15^{\circ}$ C. | = 0.8614; | rotation $a_D - 9.5^{\circ}$ . |
| Second     "     "     "                   | = 0.8717; | "     " $a_D - 24.6^{\circ}$ . |
| Third     "     "     "                    | = 0.9545; | "     "     not taken.         |

The above samples were mixed together and stored in the dark, and in August, 1919, the oil was again analysed. Very little alteration had taken place during the twenty years it had been kept, and 70 per cent. distilled below  $190^{\circ}$  C.

The crude oil had sp. gr. at  $15^{\circ}$  C. = 0.8980; rotation not taken; refractive index at  $20^{\circ}$  = 1.4805.

Rectified portion     "     "     " = 0.8668; rotation  $a_D - 10.3^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4705.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 10 per cent.

### 138. *Eucalyptus fraxinoides*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1898, p. 413, t. XIX.)

White Ash.

**Systematic.**—A tall tree, bark rough half-way up the trunk, and sometimes the upper part, outer layer falling off in ribbons, the bark blotched. Abnormal leaves alternate, varying from bluntly lanceolate to almost linear-lanceolate, slightly falcate. Normal leaves lanceolate, often falcate, acuminate, sub-coriaceous, averaging 3 inches in length; intramarginal vein somewhat removed from the edge, lateral veins oblique. Buds ovoid when young; as growth proceeds



the operculum is more or less pointed at the top, and thus assuming a somewhat conical shape; up to seven or eight flowers in the umbel, peduncles flattened.

**Fruit.**—Shining, nearly globular, urceolate in young fruit, the neck being almost lost in the mature fruit; rim sharp; valves usually five and very depressed; usually 5 lines in diameter, or a little less.



*Care is required not to confound the fruits with those of E. stricta and E. obtusiflora or even E. maculata.*

**Habitat.**—Mountains in the Clyde district, Tantawanglo, Milton, N.S.W.

**REMARKS.**—The affinity of this species in the herbarium is closest with *E. obtusiflora* and *E. stricta*. It differs conspicuously from these in being a large tree. Morphology is of little or no assistance in determining this species, for the dried material is almost identical with those species, but the two are mallees and the other a tree. It is a suitable tree for temperate climates. The fruits are sometimes not very dissimilar in shape to those of *E. maculata*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, N.S.W., in August, 1898. The yield of oil was 0.98 per cent. The crude oil was but slightly coloured, resembling in this respect those of *E. dives*, *E. radiata*, &c. The oil consisted largely of phellandrene, and pinene was present in small amount. Cineol occurs, but not more than 5 or 10 per cent. in the crude oil. Crystallised eudesmol was detected, and the third fraction contained it in some quantity. The peppermint constituent was also present. The esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.8687; rotation  $a_D$  — 27.5°; refractive index at 20° = 1.4851, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 3.7.

On rectification, 1 per cent. distilled below 172° C. (corr.). Between 172°–183°, 79 per cent. distilled; between 183–224°, 12 per cent. distilled, and between 224–278°, 5 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8590; rotation  $a_D$  — 31.6°.

Second „ „ „ = 0.8725; „ „  $a_D$  — 26.9°.

Third „ „ „ = 0.9188; „ „ not taken.

The third fraction also contained a constituent which had a strong lemon odour, and as an aldehyde was present, it is probable that citral occurs in small amount in the oil of this Eucalypt.

The above sample of oil had been stored in the dark, and in September, 1919, was again analysed. The specific gravity had increased a little, and the optical activity diminished also. This appears to be due to the alteration in the phellandrene. Perhaps the cineol had also increased a little, but altogether not much alteration had taken place during the twenty-one years the oil had been kept. 81 per cent. distilled below 190° C.

The crude oil had sp. gr. at 15° C. = 0.8862; rotation  $a_D$  — 15.7°; refractive index at 20° = 1.4871.

The rectified portion „ „ = 0.8655; rotation  $a_D$  — 26.1°; refractive index at 20° = 1.4811.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 17 per cent. As piperitone was present, a ketone determination was made in the rectified portion, with the result that 6 per cent. was absorbed. Thus about 12 per cent. of cineol was present in the oil of this species,

## 139. *Eucalyptus macrorhyncha*.

(F.v.M., in B.Fl., iii, 207.)

**Red Stringybark.**

**Systematic.**—A tall tree, bark compact, coarse, stringy, blackish on the outer surface. Abnormal leaves ovate to lanceolate, falcate, shortly acuminate, about 6 inches long and 2 inches broad; venation well marked, lateral veins few, spreading, intramarginal vein removed from the edge. Normal leaves oblique, lanceolate, or ovate-lanceolate, generally under 6 inches long, slightly shining; venation distinct, lateral veins oblique, few, spreading, in the broader leaves the intramarginal vein is well removed from the edge. Peduncles axillary, up to 1 inch long, flattened, bearing about half-a-dozen flowers. Calyx tube angular, often 6 lines long, including the pedicel; operculum of two forms: (a) conical, with a sharp constriction above the calyx rim, 3 lines long; (b) hemispherical, shortly acuminate, about 2 lines long.

**Fruit.**—Shortly pedicellate, hemispherical, to pear-shaped, slightly ribbed; rim strongly domed; valves sharp-pointed and well exerted; up to 6 lines in diameter.



*The fruit of E. macrorhyncha is so characteristic that the species is very rarely, if ever, confounded with any other Eucalyptus, and it can easily be identified from the accompanying plate. The large fruited form figured in the 1st Edition has since been raised to specific rank under the name of E. Cannoni.*

**Habitat.**—Rylstone district, Bungendore to Victorian boundary, Barber's Creek, New South Wales; and all the Eastern States.

**REMARKS.**—Our researches show that this species is superior to most of its congeners in the number of its economics. In addition to its timber and bark it yields (1) eudesmol, (2) an oil occasionally containing 50 per cent. of cineol, and (3) the khaki yellow dye, myrticolorin. It is called "Red Stringybark" in allusion to the colour of its timber, as compared to that of other "Stringybarks," such as *E. eugenoides*, Sieb., *E. capitellata*, Sm., and *E. laevopinea*, R.T.B.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from the Rylstone District, N.S.W., at various times during March, 1898, from which nine separate distillations were made. The oils of all these samples were in agreement, and the yields averaged 0.29 per cent. The crude oil was reddish-brown in colour, and had an odour resembling those belonging to the cineol-phellandrene group. A small quantity of pinene occurs in the oil of this species, and phellandrene was present also, occurring in greatest amount during the early spring months. Cineol was present in some quantity at certain times of the year. Eudesmol was often a pronounced constituent, and it was from the oil of this species that this stearoptene was first obtained in sufficient amount for investigation. The sesquiterpene was pronounced in the higher-boiling portion.



The mixed crude oils of all the samples had specific gravity at 15° C. = 0.929; refractive index at 20° = 1.4745, and was soluble in 2 volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 8.4.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–176°, 23 per cent. distilled; between 176–186°, 32 per cent. came over; between 186–268°, 11 per cent. distilled, and between 268–289°, 27 per cent. distilled. These fractions gave the following results:—

|                                                                      |  |
|----------------------------------------------------------------------|--|
| First fraction, sp. gr. at 15° C. = 0.9025; rotation $a_D$ — 1.0°.   |  |
| Second    "       "       "       = 0.9079;       "       inactive.  |  |
| Third     "       "       "       = 0.9132;       " $a_D$ + 1.4°.    |  |
| Fourth    "       "       "       = 0.9564;       "       not taken. |  |

The cineol, determined by the phosphoric acid method in the oil distilling below 186°, was 52 per cent., indicating about 30 per cent. in the crude oil (O.M.).

**Myrticolorin.**—The leaves of *E. macrorhyncha* contain a large amount of a yellow dye material, discovered by one of us in 1897. (Proc. Roy. Soc., N.S.W.) It was there named Myrticolorin. Its chemistry was afterwards described in a paper (Journ. Chem. Soc., 1898, p. 697). It is a glucoside of quercetin, having the formula  $C_{27}H_{30}O_{16}$  and on hydrolysis breaks down into quercetin, glucose, and rhamnose by the following reaction:— $C_{27}H_{30}O_{16} + 3 H_2O = C_{15}H_{10}O_7 + C_6H_{12}O_6 + C_6H_{14}O_6$ .

*Osyritrin*, *Viola-quercetin* and *Rutin*, are analogous substances. Myrticolorin gives colours, when mordanted, resembling those obtained similarly with the better qualities of flavin, and decidedly purer than those given by quercitron bark itself, or with fustic. The colours are quite fast to light and to milling. The extraction of myrticolorin from the leaves of this *Eucalyptus* is exceedingly simple, but it is important that the leaves be ground to a very fine powder. When the powdered leaves are boiled and filtered boiling hot, the myrticolorin passes with the filtrate, but crystallises out again on cooling, as it is very slightly soluble in cold water. The tannins and other bodies extracted at the same time remain in solution, and can be removed by filtration; the myrticolorin can then be washed with cold water, pressed, dried, and powdered. A determination, on a semi-commercial scale, gave at the rate of 8½ lbs. of dried myrticolorin from 100 lbs. of powdered leaves, collected as would be done for commercial oil distillation. *Eucalyptus macrorhyncha* is a common tree in New South Wales and Victoria, so that there is an abundance of material available.

The presence of this dye material in the leaves of *E. macrorhyncha* at once distinguishes it from *E. levopinea*, and is another illustration of the value of chemical evidence in determining differences between *Eucalyptus* species closely allied morphologically. Traces of this dye have been detected in the leaves of other species, but, so far, the amount has not been determined. It may be found eventually, however, that *E. macrorhyncha* does not give the maximum yield of this dye material, particularly as the leaves of some species become quite yellow when dry.



## 140. *Eucalyptus capitellata*.

(Sm., in Bot. Nov. Holl., 42, and in Trans. Linn. Soc., iii, 285.)

**Brown Stringybark.**

**Systematic.**—A large tree, bark fibrous, stringy, brownish. Abnormal leaves lanceolate, straight, pale-coloured; venation fine, oblique, parallel, distant, intramarginal vein removed from the edge, which is sometimes crenulate. Normal leaves shining, 3 to 6 inches long, oblique, lanceolate, falcate; venation faintly marked, transverse veins oblique, parallel, distant, intramarginal vein removed from the edge. Peduncles axillary, with six to twelve sessile flowers. Calyx tube thick, with almost parallel sides, about 4 lines long, and 2 lines in diameter; operculum hemispherical, obtuse.

**Fruit.**—Sessile, compressed, globose; rim domed; valves slightly exserted; under 6 lines in diameter.

*These compressed fruits at once determine the species both in herbarium and field. E. eugenioides, only in very exceptional cases, has sessile fruits which might be mistaken for those of this species.*



**Habitat.**—Coast district and Dividing Range, New South Wales; South Australia; Victoria.

**REMARKS.**—The name "Brown Stringybark" is used comparatively in connection with the timber of *E. macrorhyncha*, F.v.M., *E. eugenioides*, Sieb., and *E. laevopinea*, R.T.B.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Canterbury, N.S.W., in August, 1897. The yield of oil was 0.11 per cent. The crude oil was red in colour, and had a somewhat rank odour. Cineol was present, and phellandrene also detected, but that terpene was only present in small amount. Pinene was present in the dextro-rotatory form. The higher-boiling portion consisted largely of the sesquiterpene, but crystallised eudesmol was not detected. Esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.9175; rotation  $\alpha_D + 4.4^\circ$ ; refractive index at 20° + = 1.4771, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 4.3.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–175°, 22 per cent. distilled; between 175–193°, 44 per cent. distilled; between 193–269°, 7 per cent. came over, and between 269–277°, 17 per cent. distilled. These fractions gave the following results:—

|                                   |           |                                    |
|-----------------------------------|-----------|------------------------------------|
| First fraction, sp. gr. at 15° C. | = 0.8952; | rotation $\alpha_D + 6.52^\circ$ . |
| Second " " "                      | = 0.9014; | " + 3.20°.                         |
| Third " " "                       | = 0.9142; | " not taken.                       |
| Fourth " " "                      | = 0.9482; | " not taken.                       |

The cineol was determined by the phosphoric acid method in the portion distilling below 193° C. The result was 38 per cent., indicating about 25 per cent. in the crude oil (O.M.).

The above sample was stored in the dark, and in December, 1919, was again analysed. Very little alteration had taken place in the oil during the twenty-two years it had been kept, and evidently constituents prone to alteration are practically absent in the oil of this species. There was apparently no increase in cineol. 64 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results :—

Crude oil, sp. gr. at 15° C. = 0.9197; rotation  $a_D + 5.0^\circ$ ; refractive index at 20° = 1.4775.

Rectified portion „ = 0.8996; rotation  $a_D + 5.4^\circ$ ; refractive index at 20° = 1.4654.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 32 per cent. By the rapid phosphoric acid method, the result was 26 per cent. when calculated for the crude oil.

## 141. *Eucalyptus acmenioides*.

(Schau., in Walp. Rep., ii, 924.)

White Mahogany.

**Systematic.**—A tall tree, with a lightish-coloured stringybark. Leaves lanceolate, thin, mostly about 4 inches long and 1 inch wide, dark green on the upper surface, pale underneath, sometimes shining; venation distinct, in relief on the under surface of leaf, lateral veins oblique, parallel or spreading, intramarginal vein removed from the edges. Flowers axillary, peduncles flattened, about six in each umbel; pedicels about 3 lines long, angled. Calyx tube turbinate, about 2 lines in diameter, and 2 lines long; operculum acuminate, shorter than the calyx.

**Fruit.**—Pedicellate, hemispherical; rim usually thin, slightly sunk; valves not exerted, the cells very distinct; 3 lines in diameter.

*The nearest fruits in shape to these are (when immature) E. umbra [1], next E. Bosistoana, E. melliodora and E. carnea.*



**Habitat.**—Coast district, New South Wales; Queensland.

**REMARKS.**—This is a distinct species, but care must be taken in the herbarium not to confuse it with *E. carnea* and *E. umbra*, R.T.B., as the early fruits of these species greatly resemble each other. These latter species differ from it in (1) young state leaves, (2) their normal leaves being coarse and thick, and with a uniform greyish colour on both sides, (3) the mature fruits having a thick rim, whilst the timber and oils of all three are also distinct. These species preserve a constancy of specific characters throughout their geographical range.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Lismore, N.S.W., in August, 1900. The yield of oil was small, only 8½ oz. being obtained from 594 lb. of leaves; equal to 0.09 per cent. The



crude oil was dark orange-brown in colour, and had a very rank odour. It contained a large amount of the sesquiterpene. Pinene was present, and phellandrene also. Only a minute quantity of cineol could be detected in the first fraction. The oil was somewhat viscous, due to the sesquiterpene. It may be mentioned that the viscosity of crude Eucalyptus oils varies much, from that of turpentine to that of olive oil.

The crude oil had specific gravity at 15° C. = 0.9252; refractive index at 20° = 1.5008, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 8.6.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–183°, 25 per cent. distilled; between 183–250° 18 per cent. came over, and between 250–290°, 43 per cent. distilled. These fractions gave the following results:—

|                                  |                             |                              |
|----------------------------------|-----------------------------|------------------------------|
| First fraction,                  | sp. gr. at 15° C. = 0.8628; | rotation $a_D + 5.5^\circ$ . |
| Second    ,,        ,,        ,, | = 0.8751;                   | ,,        + 1.2°.            |
| Third     ,,        ,,        ,, | = 0.9560;                   | ,,        not taken.         |

The oil from this species had little resemblance to that of *E. carnea*.

## 142. *Eucalyptus Planchoniana*.

(F.v.M., Fragm. xi, 43, Eucalyptographia, Dec. 4.)

### A Stringybark.

**Systematic.**—A tall tree, with a fibrous bark, much resembling *E. obliqua* and *E. fastigata*. Abnormal leaves large, sometimes 1 foot long and 2 inches broad, lanceolate, drying almost "khaki" colour; venation distinct, spreading, intramarginal vein removed from the edge. Normal leaves rigid, lanceolate, falcate, pale-coloured; venation similar to that of abnormal leaves. Branchlets distinctly quadrangular, almost winged. Peduncles axillary, much flattened, nearly 3 lines broad, with four to six flowers. Calyx tube ribbed, tapering downwards to a short thick pedicel, 4 lines in diameter; operculum ribbed, conical, obtuse, under 6 lines long.

**Fruit.**—Large, shortly pedicellate, irregularly urceolate and ribbed, contracted towards the narrow or countersunk rim; valves deeply sunk; slightly over 1 inch long and 9 lines in diameter.

*The fruits are not unlike some of the Bloodwoods, such as E. calophylla, a large form of E. eximia or E. intermedia.*

**Habitat.**—Woodburn and Evans River, New South Wales; Queensland. A species very limited in its geographical distribution.



**ESSENTIAL OIL.**—Leaves were obtained from Woodburn, N.S.W., in August, 1900. The yield of oil was very small, only 1½ oz. being obtained from 675 lbs. of leaves, equal to 0.014 per cent.



The crude oil was red in colour, and had a somewhat rank odour, difficult to define; the secondary odour was not aromatic. It contained phellandrene in fairly large quantity, and cineol appeared to be absent. From the colour reaction with phosphoric acid and also with bromine, together with the specific gravity of the crude oil, there appeared to be a fair amount of the sesquiterpene present. The specific gravity of the crude oil at 15° C. = 0.9039. Owing to the dark colour of the oil, light did not pass. The saponification number for the esters and free acid was 7.1. Although the oil was insoluble in 10 volumes 70 per cent. alcohol, yet it cleared with 1 volume 80 per cent., thus indicating the presence of alcoholic bodies in the higher-boiling portion.

### 143. *Eucalyptus pilularis*.

(Sm., in Trans. Linn. Soc., iii, 284; B.Fl., iii, 208.)

Blackbutt.

**Systematic.**—One of the tallest trees of the Genus. Leaves thick, shining, sometimes over 6 inches long, lanceolate, falcate, oblique, drying a very pale colour; venation indistinct, lateral veins parallel, intramarginal vein removed from the edge. Flowers on axillary, flattened peduncles of about 6 lines long, mostly six in the umbel. Calyx tube slightly over 2 lines in diameter, pear-shaped, on a pedicel of from 2 to 3 lines long; operculum about 3 lines long, hemispherical or acuminate.

**Fruit.**—Pedicellate, semi-globose, truncate; rim sometimes contracted, thin, countersunk or broad and even domed; valves not exerted; about 5 lines in diameter.



*These fruits are very close in form to E. dextropinea, but the rim in the latter case is generally broader and the former mostly countersunk.*

**Habitat.**—Coast district and Tableland, New South Wales; Victoria; Queensland.

**REMARKS.**—"Blackbutt" is a tree well known to timber getters and the trade, and offers no difficulties of determination either in the field or the herbarium, for in the latter it can be named from the leaves alone. The bark varies a little, sometimes being dark-coloured, compact-stringy, and at other times light reddish coloured and loosely stringy.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from the following New South Wales localities:—Canterbury, in June, 1897; Canterbury, in August, 1898; Belmore, in November, 1898; and Currawang Creek, in November, 1898. The yields of oil from these localities varied between 0.08 and 0.18 per cent. The crude oils were of a light-amber colour, with a rank odour, difficult to define. Phellandrene was present, but cineol detected only in very small quantity (5 to 10 per cent.). Pinene was only present in small amount. The higher-boiling portion consisted largely of the sesquiterpene, and it also contained a quantity of the liquid form of eudesmol; this was shown by the increased dextro-rotation. After the oil was acetylated, it had a high saponification number, indicating the presence of free alcoholic bodies, and the saponified oil was also somewhat aromatic. This high-boiling alcohol is characteristic of the oils of several *Eucalyptus* species, and its presence is shown by the high rotation figures of the higher-boiling fractions. The crystallised form of eudesmol was not

detected, under ordinary circumstances, in the oils of this species. The lævo-rotation of the first fraction, caused by the presence of the phellandrene, distinguishes this species from *E. dextropinea*. The varying amounts of phellandrene and pinene, the one lævo- and the other dextro-, cause the rotation of the oils distilled at different times of the year to be not constant, the lævo-rotation of the phellandrene, when this terpene is pronounced, overcoming the dextro-rotation of the pinene, and the phellandrene, having such a high optical rotation, becomes more active in this way than does the pinene. The eudesmol also influences the rotation to the right.

The following results were obtained with the August sample. The specific gravity of the crude oil at 15° C. = 0.8935; rotation  $a_D + 5.8^\circ$ ; refractive index at 20° = 1.4904, and was not soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 5.9.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–183°, 50 per cent. distilled; between 183–204°, 16 per cent. came over, and between 204–280°, 25 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8595; rotation  $a_D - 11.6^\circ$ .

Second „ „ „ = 0.8662; „ „  $- 9.9^\circ$ .

Third „ „ „ = 0.9410; „ „  $+ 20.9^\circ$ .

The third fraction was acetylated, when the saponification number had risen to 56.4, showing the presence of about 23 per cent. of the liquid form of eudesmol in this fraction.

Belmore and Currawang Creek are far apart, but the results obtained with the oils from those localities differed but little from the above, with the exception that the phellandrene was more pronounced in the Belmore sample, and the alcohols in that from Currawang Creek.

The general results obtained with the four samples of oil are here tabulated.

| Sample.                                             | Yield<br>per cent. | Specific<br>Gravity,<br>Crude Oil<br>at 15° C. | Specific<br>Gravity,<br>First<br>Fraction at<br>15° C. | Optical<br>Rotation<br>$a_D$<br>Crude Oil. | Optical<br>Rotation<br>$a_D$<br>First<br>Fraction. | Solubility,<br>Crude Oils.                                   |
|-----------------------------------------------------|--------------------|------------------------------------------------|--------------------------------------------------------|--------------------------------------------|----------------------------------------------------|--------------------------------------------------------------|
| <i>E. pilularis</i> , Canterbury,<br>12-6-97.       | 0.103              | 0.889                                          | .....                                                  | $+7.6^\circ$                               | .....                                              | Required 8<br>vols. 80 per<br>cent.                          |
| <i>E. pilularis</i> , Canterbury,<br>11-8-98.       | 0.078              | 0.894                                          | 0.8595                                                 | $+5.8^\circ$                               | $-11.6^\circ$                                      | Not quite clear<br>with 10 vols.<br>80 per cent.<br>alcohol. |
| <i>E. pilularis</i> , Belmore,<br>7-11-98.          | 0.176              | 0.885                                          | 0.8570                                                 | $-4.2^\circ$                               | $-20.6^\circ$                                      | Required 8<br>vols. of 80<br>per cent.                       |
| <i>E. pilularis</i> , Currawang<br>Creek, 24-11-98. | 0.069              | 0.903                                          | 0.8577                                                 | $+11.1^\circ$                              | $-16.2^\circ$                                      | Not quite clear<br>with 10 vols.<br>80 per cent.             |

The varying effects on the rotations of Eucalyptus oils by the optically active constituents with opposite rotations is well demonstrated with those from this species, and this peculiarity is very apparent with oils having phellandrene as a pronounced constituent, when pinene is also present in quantity.



The above oils were mixed together and stored in the dark, and in August, 1919, twenty-one years afterwards, the oil was again analysed. Not much alteration had taken place during all that time, as the figures below will show, and the reaction for phellandrene was just as pronounced as formerly. 66 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.8945; rotation  $a_D + 1.0^\circ$ ; refractive index at 20° = 1.4904.

Rectified portion „ = 0.8624; rotation  $a_D - 14.2^\circ$ ; refractive index at 20° = 1.4801.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 11 per cent.

## 144. *Eucalyptus obliqua*.

(L'Her., in Sert. Angl., 18, t. 20.)

(Syn. *E. gigantea*, Hook. f.; *E. falcifolia*, Miq.; *E. nervosa*, F.v.M.)

**Stringybark.**

**Systematic.**—One of the largest trees on the Australian continent and in Tasmania. Bark stringy, and not to be distinguished from that of other Eucalypts to be found in that cortical class of Eucalypts. Abnormal leaves oblique, oval to ovate-lanceolate, shortly acuminate, petiolate, pale-coloured underneath, shining on the upper surface; venation distinct. Normal leaves lanceolate, falcate, oblique, measuring from 6 to 10 inches long and 1 inch to over 2 inches wide; venation distinct, lateral veins often very oblique, intramarginal veins removed from the edges. Peduncles axillary, about 12 lines long, flattened, bearing numerous flowers. Calyx tube conical, from 1 to 2 lines in diameter, tapering to a short pedicel; operculum hemispherical, acuminate.

**Fruit.**—Urn-shaped, or pyriform to hemispherical, variable as to size, shortly pedicellate, contracted at the rim, which is thin and countersunk; valves not exserted; sometimes over 6 lines long and 4 lines wide.



*The pear-shaped fruit much resembles that of E. Delegatensis, and the hemispherical that of E. regnans. Its connection with E. gigantea, Hook. f., is fully dealt with in our paper on Tasmanian Eucalypts and their Essential Oils, Roy. Soc. Tas., 1912.*

**Habitat.**—Tableland from Queensland into Victoria, at high elevations; South Australia; Tasmania.

**REMARKS.**—This tree was the first Eucalyptus made known to science, and it was on this species that the Genus was founded by L'Héritier. The original specimens came from Tasmania, but it occurs over extensive areas in Victoria and in the New South Wales Coast Ranges. Its botanical and chemical characters are constant throughout this extensive range. It derives its specific name from the unequal halves of its leaves; but this is not a good specific character, as several other Eucalypts have this particular feature well marked. Though much resembling in size, general appearance, and bark, two other species, i.e., *E. fastigata*, H.P. & J.H.M., and *E. Delegatensis*, R.T.B., with which it is also associated, yet, nevertheless, in the field it is easily distinguished from them by its very broad and rich green abnormal or young state leaves, and by the fact that the persistent bark runs nearly right out to the branchlets, which is not the case in the two other species.



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, N.S.W., in August, 1898. The yield of oil was 0.68 per cent. The crude oil was reddish-brown in colour, and had a rank terpene-like odour, far from pleasant. The principal constituent in the oil was phellandrene, and pinene appeared to be almost absent. Cineol was only present in small amount. A characteristic constituent occurring in the oil of this Eucalypt is the aldehyde aromadendral, and it thus differs from most other phellandrene-bearing oils, obtained from such species as *E. dives*, *E. Sieberiana*, &c., in that the peppermint constituent piperitone replaces in these the aromadendral as a distinguishing constituent. The rectified oil had a yellowish tint, due to the influence of the predominating phenol.

The crude oil had specific gravity at 15° C. = 0.8902; rotation not taken; refractive index at 20° = 1.4877; and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 8.03.

On rectification, only 1 per cent. came over below 175° C. (corr.). Between 175–183°, 58 per cent. distilled; between 183–214°, 22 per cent. came over, and between 214–245°, 12 per cent. distilled. The third fraction contained aromadendral. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8707; rotation  $\alpha_D$  — 25.67°.  
 Second    "       "       "       = 0.8810;       "       — 24.24°.  
 Third     "       "       "       = 0.9286;       "       not taken.

Later, in July, 1908, material of this species for distillation was collected at Mt. Wellington, Tasmania, at an altitude of about 2,000 feet; and also at about the same time of the year at Williamsford, on the west coast of Tasmania. Both the crude oils were of a reddish-brown colour, due to the action of the iron from the still acting on the phenols, and both contained similar constituents in practically the same amounts, thus being in comparative agreement. The results also agreed with those obtained with the oil of this species from Monga, New South Wales, recorded above. The chief constituent in the oil of this species was phellandrene, and the high-boiling aromatic aldehyde (aromadendral) occurred in some quantity. Cineol was present only in small amount, and both eudesmol and piperitone appeared to be absent. The following tabulated results for the crude oils from the two Tasmanian localities show how closely they agree.

|                                                       | Mt. Wellington.                  | Williamsford.                    |
|-------------------------------------------------------|----------------------------------|----------------------------------|
| Yield of oil   ...   ...   ...   ...   ...   ...      | 0.66 per cent.                   | 0.66 per cent.                   |
| Phellandrene   ...   ...   ...   ...   ...   ...      | Abundant                         | Abundant.                        |
| Aromadendral   ...   ...   ...   ...   ...   ...      | Pronounced                       | Pronounced.                      |
| Specific gravity at 15° C.   ...   ...   ...   ...    | =0.8836                          | =0.8854.                         |
| Rotation $\alpha_D$ ...   ...   ...   ...   ...   ... | —28.1°                           | —24.2°.                          |
| Refractive index at 20° C.   ...   ...   ...   ...    | =1.4870                          | =1.4861.                         |
| Soluble       ...   ...   ...   ...   ...   ...       | In 4 vols. 80 per cent. alcohol. | In 4 vols. 80 per cent. alcohol. |
| Saponification number for ester and free acid   ...   | =8.1                             | =7.2.                            |

These results, together with the botanical characters, indicate that the Tasmanian trees of this species are identical with those growing in Australia.



EUCALYPTUS OBLIQUA, L'HER.  
A STRINGYBARK.

76 Mini  
SUBARU



In August, 1912, leaves for distillation were collected by Mr. L. G. Irby, from trees which, although growing amongst *E. obliqua* on Mt. Wellington, Tasmania, at an altitude of about 1,000 feet, had a smooth top, the "stringy-bark" supposed to be characteristic for this species only reaching to the branches. The oil distilled from this material was identical in all respects with that of the typical *E. obliqua*. The yield of oil was 0.77 per cent.; specific gravity of crude oil at 15° C. = 0.8845; rotation  $a_D$  — 28.8°; refractive index at 20° = 1.4835, and was soluble in 3 volumes 80 per cent. alcohol.

The presence of aromadendral and absence of piperitone in the oil of *E. obliqua*, is a distinguishing feature, and enables these trees to be easily separated from all allied forms growing in Tasmania. It is thus seen that the persistence of the outer "stringy-bark" is only relative, and we have noticed with *E. pilularis* that the outer bark will occasionally only persist a few feet from the ground.

The Monga sample was preserved in the dark, and in November, 1919, was again analysed. Very little alteration had taken place during the twenty-one years it had been stored, and the phellandrene had only altered slightly in optical rotation. 58 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.8966; rotation  $a_D$  — 22°; refractive index at 20° = 1.4882.

Rectified portion     ,,     = 0.8723; rotation  $a_D$  — 23.7°; refractive index at 20° = 1.4817.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 15 per cent.

The cineol was removed from a portion of the rectified oil by shaking with 50 per cent. resorcinol. The remaining oil had an odour indicating cymene. It had specific gravity at 15° = 0.8621; and refractive index at 20° = 1.4858. These results indicated that both phellandrene and cymene were present, and together with the occurrence of the aromadendral, suggest that this species is more closely related to the members of the "Box" group, than are the other "Stringybarks."

## 145. *Eucalyptus crebra*.

(F.v.M., in Journ. Linn. Soc., iii, 87.)

**Narrow-leaved Ironbark.**

**Systematic.**—This ironbark often grows to a very large tree, and is the most widely-distributed of all the "Ironbarks," as it occurs on both sides of, and on the Dividing Range, as well as in the interior. Its specific characters are distinct, and it is not easily confounded with other "Ironbarks." The bark is blackish, hard, and deeply furrowed. Leaves narrow, lanceolate, mostly under 6 inches long, and about 3 lines wide, generally of a thin texture, and of equal colour on both sides; lateral veins not well marked, the intramarginal vein not quite close to the edge. Flowers mostly in panicles, appearing to form a terminal corymb. Calyx tube turbinate, about 1 line in diameter; operculum conical, equal in length to the calyx tube.

**Fruit.**—Very small on slender pedicels, semi-ovate, or sometimes attenuate at the base; rim narrow; valves not exserted; under 2 lines in diameter.

*This has one of the smallest sized fruits of the Genus, and much resemble those of E. Beyerli, E. polybractea and E. viridis.*



**Habitat.**—New South Wales; Queensland; North Australia.

**REMARKS.**—The bark of *E. crebra* is very characteristic, being very deeply furrowed, dark or black, often from 4 to 6 inches thick, and permeated throughout with kino. The leaves are narrower than those of other species of "Ironbarks." It is generally found in poor soil, and has, perhaps, a wider distribution than any other "Ironbark."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Rylstone, N.S.W., in June, 1900. The yield of oil was 0.16 per cent. The crude oil was of a light orange-brown colour, and had the odour of ordinary crude cineol-terpene Eucalyptus oils. It contained much phellandrene, and thus differed from the oil of *E. paniculata*; pinene was present, and also a fair amount of cineol. The second fraction consisted largely of phellandrene and cineol, while the third consisted principally of the sesquiterpene. Esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.8986; rotation  $a_D$  — 10.8°; refractive index at 20° = 1.4787, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 6.2.

On rectification, 2 per cent. distilled below 165° C. (corr.). Between 165–183°, 64 per cent. distilled; between 183–255°, 11 per cent. came over, and between 255–280°, 19 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8812; rotation  $a_D$  — 21.7°.

Second " " " = 0.8925; " — 17.5°.

Third " " " = 0.9330; " not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 32 per cent., indicating about 22 per cent. in the original oil (O.M.).





A TYPICAL IRONBARK.

(*Eucalyptus crebra*, F.v.M.)

A hard, rugged, compact, broadly-lenticled pattern, high-ridged bark, either black or grey on the outer surface, and always dark red inside.

The chief oil constituents of Eucalypts with barks of this character are cineol, pinene and phellandrene. In those of a few, however, phellandrene is absent, while the cineol increases considerably. This group is closely associated chemically with the "Stringybarks" and the "Peppermints."



to 1941  
ABSTRACT

## 146. *Eucalyptus siderophloia*.

(Benth., in B.Fl., iii, 220.)

**Broad-leaved or Red Ironbark.**

**Systematic.**—A tall tree, with a deeply-furrowed, black bark, which is hard and close in the mature trees, but laminated in the younger ones, and this distinguishes the tree from *E. paniculata*. Abnormal leaves very broad and coriaceous, with a strongly-marked venation. Normal leaves lanceolate, falcate, variable in size; venation prominent, the intramarginal vein near the edge of the leaf. Peduncles axillary or terminal, panicles corymbose. Calyx tube angular, turbinate, about 3 to 4 lines in diameter; operculum long, conical, acuminate or obtuse.

**Fruit.**—Turbinate, on a rather thick pedicel, angular at the base; rim thick; valves blunt, exserted; under 4 lines in diameter.

*Perhaps the nearest approach in shape amongst other species are the larger fruits of E. punctata.*

**Habitat.**—Coast district from south of Port Jackson into Queensland.



**REMARKS.**—This "Ironbark" is known by several vernacular names, but "Broad-leaved Ironbark" is the most preferable, as this comparative term distinguishes it at once from the other "Ironbarks." The abnormal leaves are particularly large and leathery, measuring many inches in the length and breadth. The bark has a laminated character not possessed by other "Ironbarks," and is generally not so deeply furrowed. The species is easy of determination both in the field and in the herbarium. The timber sometimes resembles that of *E. Fergusoni*.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Canterbury, N.S.W., in June, 1897. The yield of oil was very small, 336 lb. of leaves only giving 3 ounces of oil, equal to 0.06 per cent. The crude oil was lemon-yellow in colour, and had an aromatic odour difficult to define. It contained phellandrene, and pinene was present also. Only a minute quantity of cineol was detected, but the amount of oil at our disposal did not admit of rectification. The presence of an alcohol was shown by acetylating the crude oil. The specific gravity of the crude oil at 15° C. = 0.9067; optical rotation  $a_D + 14.5^\circ$ ; refractive index at 20° = 1.4943. The saponification number for the original ester, together with the free acid, was 4, while that of the esterised oil was 41.9, thus 37.9 represented the saponification number of the esters due to the free alcohols present; if calculated for  $C_{10}H_{18}O$ , this represents 10.7 per cent. The crude oil did not form a clear solution with 10 volumes 80 per cent. alcohol.

## 147. *Eucalyptus melanophloia*.

(F.v.M., in Journ. Linn. Soc., iii, 93.)

**Silver-leaved Ironbark.**

**Systematic.**—A small tree with a blackish, persistent, sometimes deeply-furrowed bark; with foliage, inflorescence, and fruits all glaucous. Leaves glaucous or olive green, sessile opposite, or petiolate alternate, from cordate-ovate or orbicular to narrow lanceolate, acuminate. Peduncles  $1\frac{1}{2}$  to 2 inches long, flowers in axillary cymes or terminal corymbs. Calyx tube slightly angular and of equal diameter; operculum obtusely conical, shorter than the calyx tube.

**Fruit.**—On a slender pedicel, pear-shaped or globular, contracted at the orifice; rim thin; valves not exserted or only slightly so; up to 3 lines in diameter.



*These fruits resemble E. intertexta or a small form of E. cærulea.*

**Habitat.**—Angledool, Narran River, Narrabri, Cassilis and Nyngan, New South Wales; Queensland.

**REMARKS.**—As this species was originally described from trees from the northern part of the State, where it is easily distinguished by its sessile, opposite, nearly white leaves, the leaf variation of the southern form was not noted. The foliage of this tree is, therefore, *not so constant in shape as was originally supposed*, for in the far interior of the State, where the trees become stunted, the leaves are small lanceolate, and of a pale brownish or olive-green colour. See paper by R. T. Baker, Proc. Linn. Soc., 1902, p. 225.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Narrabri, N.S.W., in June, 1901. The yield of oil was 0.11 per cent. The crude oil was reddish in colour, and had an odour strongly indicating cymene. The presence of volatile aldehydes was not marked, but much phellandrene was present, and pinene was also pronounced. Cineol was detected, but in very small amount, not more than 5 to 10 per cent. in the crude oil. The higher boiling portion contained a quantity of the sesquiterpene, and also the liquid form of eudesmol. This is indicated by the dextro-rotation of the fourth fraction. A secondary odour of cinnamon was detected in the portion boiling at about  $240^{\circ}$  C.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.8959; rotation  $a_D - 23.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4893, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 11.

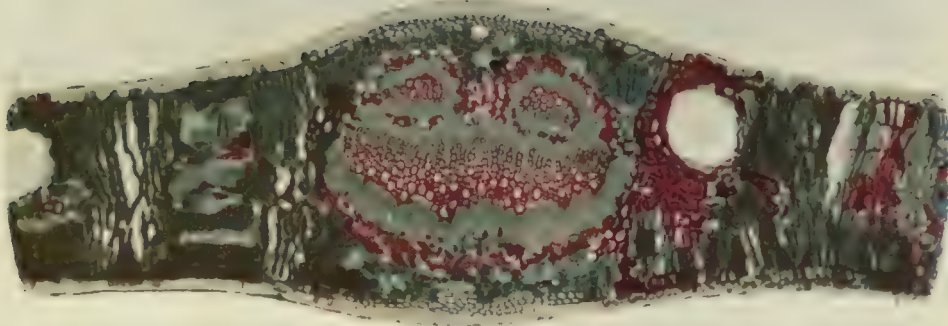
On rectification, 2 per cent. distilled below  $162^{\circ}$  C. (corr.). Between  $162-172^{\circ}$ , 25 per cent. distilled; between  $172-178^{\circ}$ , 33 per cent. distilled; between  $178-245^{\circ}$ , 6 per cent. came over, and between  $245-268^{\circ}$ , 30 per cent. distilled. These fractions gave the following results:—

|                                                                                      |
|--------------------------------------------------------------------------------------|
| First fraction, sp. gr. at $15^{\circ}$ C. = 0.8583; rotation $a_D - 37.5^{\circ}$ . |
| Second " " " = 0.8610; " " $- 40.7^{\circ}$ .                                        |
| Third " " " = 0.8954; " not taken.                                                   |
| Fourth " " " = 0.9352; " $a_D + 8.0^{\circ}$ .                                       |

That the oil contained alcoholic bodies is shown by the results obtained on acetylating the crude oil, which then gave a saponification number 27.8, an increase in ester value of 16.8. Assuming the alcohol to be eudesmol, the percentage in this constituent exceeded 6 per cent. in the crude oil.

There seems little doubt but that cymene was present, as on boiling a portion of the second fraction in dilute nitric acid for several hours, two acids were





Leaf of  
*Eucalyptus fergusonii*

A transverse section of the leaf of this Ironbark cut through the mid-rib. Most Ironbarks give a low yield of oil, and this species is no exception. The coriaceous character of the leaf is marked by the compact palisade parenchyma, and limited spongy tissue. The supporting tissue to the mid-rib is seen to be restricted, but the woody fibres (red) almost form a complete circle around the bundle, which is bicollateral. On the right of the central vascular bundle is seen an apparent lignification of the palisade tissue, due most probably to pathological affection.

x 60.

**EUCALYPTUS FERGUSONII, R.T.B.**



eventually obtained; one was insoluble in alcohol and ether and sublimed, the other was soluble in hot water, in alcohol, and in ether, and when purified, melted at 176° C. The acids thus indicated were p-toluic and terephthalic.

The above sample had been stored in the dark, and in October, 1919, was again analysed. Scarcely any alteration had taken place in the character and constituents of the oil during the eighteen years it had been kept, and there was no increase in cineol. 60 per cent. distilled below 190° C.

The crude oil had sp. gr. at 15° C. = 0.9004; rotation  $a_D$  — 20.4°; refractive index at 20° = 1.4897.

The rectified portion „ = 0.8648; rotation  $a_D$  — 35.6°; refractive index at 20° = 1.4774.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 5 per cent.

## 148. *Eucalyptus cærulea*, sp. nov.

Stunted Ironbark.

**Systematic.**—Only a medium-sized tree, with a black-furrowed bark, glaucous throughout, except the bark. Leaves mostly ovate-lanceolate, shortly acuminate or rounded, to lanceolate, always glaucous, coriaceous, up to 4 inches long; intramarginal vein not much removed from the edge, lateral veins running at an angle of 45° from the mid-rib; petioles slender, up to  $\frac{3}{4}$  inch long. Buds up to six in umbel, each on a slender pedicel, the common peduncle very slender, nearly 9 lines long; calyx tube tapering very gradually to the pedicel; operculum conical, acuminate, much shorter than calyx tube.

**Fruit.**—Acuminate, pyriform, contracted at opening, on slender pedicels; rim truncate, slightly concave, sometimes much raised towards the centre, having a domed appearance and a sharp-edged rim; valves deeply inserted; up to 5 lines long and 4 lines broad.

*The nearest resemblance to these fruits amongst Eucalypts are E. melanophloia or E. Fergusoni.*



**Habitat.**—Murrumbo, New South Wales.

**REMARKS.**—In the first Edition this species was placed by us as Bentham's (B. Fl. vol. iii, p. 210) variety of *E. sideroxylon*, i.e. var. *pallens*, but the physical, field, and chemical characters are sufficiently different, we think, to raise it to specific rank. It appears to be quite restricted to the locality where it was first discovered by us, as no other specimens have come to hand. It is very picturesque, with its silvery leaves, gnarled branches, and very black, deeply furrowed bark. It never attains a large size, being of quite stunted, gnarled growth, and the timber is not valued, as the tree is nearly always decayed in the centre. Locally it is always regarded as distinct from *E. sideroxylon*.

We, however, are convinced now that it is not Bentham's var. *pallens* of *E. sideroxylon*, which Mr. Maiden has since raised to specific rank under the name of *E. Caleyi*, Proc. Linn. Soc. N.S.W., XXX, 512 (1905). A species further dealt with by this author in his Crit. Rev. Euc., vol. ii, p. 95 (1914), and For. Flor., vol. vi, p. 86 (1917).

It will readily be seen by the fruits C. and E. Plate 207 of the later work that they differ considerably from D. same plate, which latter are from Rylstone, Murrumbo, and were given to Mr. Maiden by us under the name of *E. sideroxylon*, var. *pallens*. *E. Caleyi* is a tall Ironbark, whilst this species is quite a stunted, gnarled tree, and is not known as an Ironbark locally, as the timber possesses none of the qualities of an Ironbark, and the only resemblance



to any tree of that group is the fruit which may be said to match somewhat those of *E. sideroxylon*. Mr. Maiden states that his *E. Calyi* "is locally esteemed and apparently a timber of good quality" (Crit. Rev.). In For. Flor. "the timber is red in colour, locally esteemed and apparently a timber of good quality." Such qualities will not apply to this species.

It differs from *E. Calyi* (1) in the foliage, which is always very glaucous, (2) in the shape and size of the leaves, which are always smaller and less lanceolate than obtains in that species and are of uniform shape throughout both the early leaves and late, (3) in the venation, the intramarginal vein not being "a considerable distance from the edge" as obtains in *E. Calyi*. Neither are the "veins prominent and wide apart," but are indistinct, and in some cases so hidden as not to be discernible at all, but lost in the leaf material. (4) The flowers, stalks, and peduncles are almost filiform, whilst those of *E. Calyi* are much stouter, (5) the operculum is acuminate, almost from the base of the apex.

The fruits more closely approach those of *E. melanophloia* and *E. Fergusoni*.

In botanical sequence it perhaps should be placed next to *E. melanophloia*, as the fruits, and glaucousness of the leaves, buds, and fruits, and the dark, deeply furrowed bark give it some affinity to that species.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Murrumbo, N.S.W., in October, 1900. The yield of oil was 0.4 per cent. The crude oil was dark amber-coloured, and had a turpentine-like odour. Phellandrene was present in some quantity, and pinene also detected. Cineol was also present, about 20 per cent. in the crude oil. The third fraction consisted largely of the sesquiterpene. The crude oil and the third fraction were both dextro-rotatory, while the first and second fractions were lævo-rotatory. This was due to the presence of the liquid form of eudesmol, which is dextro-rotatory, it was present in considerable quantity, and thus overcame the lævo-rotation of the phellandrene. The liquid form of eudesmol appears to be the more stable, and occurs in the oils of many species in which crystals have not so far been detected.

The crude oil had specific gravity at 15° C. = 0.9158; rotation  $a_D + 12.7^\circ$ ; refractive index at 20° = 1.4827, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 6.4.

On rectification, 1 per cent. distilled below 163° C. (corr.). Between 163–183°, 61 per cent. distilled; between 183–244°, 9 per cent. came over, and between 244–275°, 25 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8954; rotation  $a_D - 5.4^\circ$ .

Second " " " = 0.9032; " "  $- 5.1^\circ$ .

Third " " " = 0.9463; " "  $+ 24.4^\circ$ .

The cineol, determined by the phosphoric acid method in the first fraction, was 26 per cent., indicating about 17 per cent. in the crude oil (O.M.).

The oil of this Eucalypt has little resemblance to that of *E. sideroxylon*.

This sample of oil had been stored in the dark, and in August, 1919, was again analysed. Scarcely any alteration had taken place in general character and constituents during the nineteen years it had been kept, except that the specific gravity had increased a little, and the rotation of the phellandrene slightly diminished. No deposit had formed, so that the constituents were stable. 60 per cent. distilled below 190° C.

The crude oil had sp. gr. at 15° C. = 0.9204; rotation  $a_D + 13^\circ$ ; refractive index at 20° = 1.4829.

The rectified portion " " = 0.8979; rotation  $a_D - 3.75^\circ$ ; refractive index at 20° = 1.4662.

The cineol was determined by the resorcinol method in the rectified portion; the result was 31 per cent. in the crude oil. By the phosphoric acid method it was 20 per cent., when calculated for the original oil.

A portion was acetylated, when the saponification number had increased to 54.2°; in the cold with two hours' contact, it was 22.2°. This result indicates about 10 per cent. free eudesmol, and 6 per cent. free geraniol.

## GROUP VII.

## CLASS (a).

In this group are placed the following EUCALYPTS yielding an oil consisting largely of phellandrene, cineol and piperitone, but in which cineol does not exceed 40 per cent:—

- |      |                   |                                        |
|------|-------------------|----------------------------------------|
| 149. | <i>Eucalyptus</i> | <i>piperita</i> .                      |
| 150. | <i>E</i>          | <i>amygdalina</i> .                    |
| 151. | <i>E.</i>         | <i>amygdalina</i> , var. <i>nitida</i> |
| 152. | <i>E.</i>         | <i>phellandra</i>                      |
| 153. | <i>E</i>          | <i>vitrea</i>                          |
| 154. | <i>E</i>          | <i>Luehmanniana</i>                    |
| 155. | <i>E</i>          | <i>coccifera</i>                       |

## 149. *Eucalyptus piperita*.

(Smith, in Trans. Linn. Soc., iii, 286 partly.)

### The Sydney Peppermint.

**Systematic.**—A tall tree, bark fibrous, but not so furrowed as in the "Stringybarks," hoary on the outer surface. Abnormal leaves ovate, ovate-acuminate, lanceolate, almost membranous, pale-coloured underneath, 2 to 6 inches long; venation faintly marked, lateral veins oblique, spreading, intra-marginal vein slightly removed from the edge. Normal leaves lanceolate, not large, rarely exceed 6 inches, oblique, not coriaceous, very acuminate, not shining; venation not prominent, lateral veins distinct, oblique, spreading, petiole slender. Flowers in axillary peduncles or panicles, or clustered at the base of the branchlets. Buds about 6 lines long. Calyx tube small, a little over 1 line in diameter, hemispherical, or slightly tapering into a pedicel a few lines long; operculum conical, acute.

**Fruit.**—Dimorphous, pilular, shortly pedicellate, sometimes contracted below the rim, when it becomes quite urn-shaped; rim thin; valves not exserted; about 3 lines in diameter.

*The fruits cannot well be confounded with any other.*

**Habitat.**—Sydney, Coast District, and Tableland, New South Wales; Victoria; Queensland.



**REMARKS.**—In this research particular interest pertains to this species, as it was from trees of the "Sydney Peppermint," growing where Sydney now stands, that the first Eucalyptus oil was obtained. It was distilled by Dr. White, Surgeon to the First Fleet, in 1788.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Gosford, N.S.W., in April, 1897. The yield of oil was 0.8 per cent. The oil was light-coloured, and had a distinct peppermint odour due to the ketone piperitone. Phellandrene was present in some quantity, as was to be expected from the characteristic venation of the mature lanceolate leaves; pinene was also found in small quantity. Cineol occurs to the extent of about 20 per cent. in the crude oil. Crystallised eudesmol was found, and it was in this oil that we discovered that constituent. The higher-boiling portion consisted largely of the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.9111; rotation  $\alpha_D$  — 2.7°; refractive index at 20° = 1.4781, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 11.0.

On rectification, 1 per cent. distilled below 170° C. (corr.). Between 170–183°, 77 per cent. distilled; between 183–198°, 9 per cent. came over; the temperature then rose rapidly to 266°. Between 266–272°, 8 per cent. distilled. The third fraction consisted largely of eudesmol.



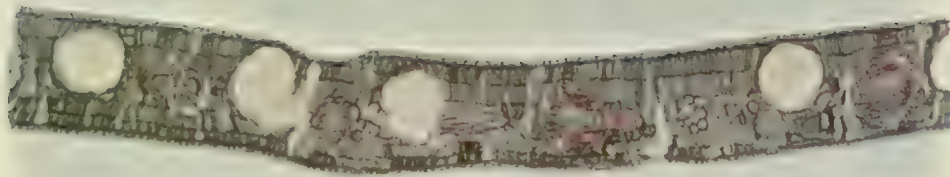


Fig. 10.  
Oil gland.

Cross section of a portion of a leaf showing the large area occupied by each oil gland (four in this case), and all situated in the palisade area of the upper portion of the leaf. The dorsal epidermis is more heavily cutinised and the palisade layers are more conspicuous towards that surface. x 55.

EUCALYPTUS PIPERITA. SM.

70 1000  
1000000000

The cineol, determined by the phosphoric acid method in the first fraction, was 25 per cent. (O.M.), indicating about 20 per cent. in the original oil.

It was from this species that the first Eucalyptus oil was obtained. This is referred to in White's "Journal of a Voyage to New South Wales, 1790," p. 266.

Material for distillation from trees that are considered to be *E. piperita*, which have urn-shaped fruits resembling in miniature those characteristic of *E. corymbosa*, was obtained from Wingello, N.S.W., in January, 1901. These trees grow extensively in that neighbourhood. The oil had resemblances to that of the type, but contained considerably more phellandrene; pinene was present, and eudesmol also detected. Cineol was present to the extent of about 10 to 15 per cent. in the crude oil.

The crude oil had specific gravity at 15° C. = 0.8785; rotation  $a_D$  — 35.5°; refractive index at 20° = 1.4772, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.8.

On rectification, 2 per cent. distilled below 167° C. (corr.). Between 167–183°, 83 per cent. distilled; between 183–225°, 7 per cent. came over, and between 225–260°, 6 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8700; rotation  $a_D$  — 39.3°.

Second " " " = 0.8877; " — 29.4°.

Third " " " = 0.9298; " not taken.

The cineol did not appear to exceed 10 or 15 per cent. in the crude oil, consequently the phosphoric acid method was not suitable for quantitative determination.

From the rotation figures it is apparent that the activity was due to the phellandrene present, but the whole results indicate that this form of *E. piperita* is closely associated with the type.

This sample from Wingello had been stored in the dark, and in September, 1919, was again analysed. Very little alteration had taken place during the eighteen years the oil had been kept. 85 per cent. distilled below 190° C.

The crude oil had sp. gr. at 15° C. = 0.8828; rotation  $a_D$  — 30.4°; refractive index at 20° = 1.4778.

The rectified portion " " = 0.8720; rotation  $a_D$  — 37.7°; refractive index at 20° = 1.4744.

The cineol was determined by the resorcinol method in the rectified portion; the result was 27 per cent., but as 5 per cent. of piperitone was also present, that amount had to be deducted, thus 22 per cent. of cineol is the corrected amount.



## 150. *Eucalyptus amygdalina*.

(Labill. in Pl. Nov. Holl., ii, 14, t. 154.)

**Black Peppermint.**

**Systematic.**—An average forest tree in height. The bark is characteristic of the "Peppermint" variety, as illustrated in this work. The abnormal leaves small, narrow, lanceolate, about 1 inch long, shortly petiolate or sessile, gradually becoming alternate, sometimes three in a whorl; venation well marked, marginal vein removed from the edge, broad ovate to lanceolate, up to 3 inches long and  $\frac{1}{2}$  inch broad, shortly petiolate or sessile, cordate. Normal leaves almost invariably lanceolate, varying in size according to locality, narrow and small to medium broad, and up to 3 or 4 inches long. Inflorescence in axillary clusters on flattened peduncles. Buds clavate; calyx pyriform; operculum rounded or flattened.

**Fruit.**—Shortly pedicellate, hemispherical, sometimes pear-shaped; rim thick, slightly domed, shiny or not; up to 3 lines long, and the same in diameter.



*The nearest approach to this capsule in shape is that of E. dives; it also somewhat resembles E. Australiana, but with care can be distinguished by the rim.*

**Habitat.**—Tasmania.

**REMARKS.**—Since first recorded by Labillardiere from Tasmania a number of species described from the mainland by various authors, have from time to time been regarded by some later systematists as synonyms. The list is too long to be published here, but will be found in botanical works and papers bearing on Eucalypts. Our investigations almost invariably go to show that most of these Eucalypts are worthy of specific rank. In our paper on the Eucalypts of Tasmania and their Essential Oils (Roy. Soc. Tas., 1912) under this tree, we mention the fact that "as far as our researches go, Labillardiere's species does not appear to occur on the mainland of Australia."

**ESSENTIAL OIL.**—Material of this species, known as "Black Peppermint," was received from various localities in Tasmania, and collected at various times of the year, in order that definite conclusions might be secured as to the specific differences between the oil of *E. amygdalina* of Tasmania, and that of trees known in New South Wales and Victoria as "Narrow-leaved Peppermint." The character of the oil of the Tasmanian tree places it in the pronounced "phellandrene group" of these oils, and it thus differs considerably from that of the Australian form. It more closely approaches, in constituents and physical properties, the oil of *E. dives*, with the exception that the oil of the Tasmanian *E. amygdalina* contains a little more cineol than does that of *E. dives*. Commercially the oil could be utilised for similar purposes to those for which that of *E. dives* is employed, but it would not pay to submit it to fractional distillation in order to separate the cineol portion, any more than it would pay to do so with the oil of *E. dives*. The yield of oil of the New South Wales form is almost twice that obtained from the Tasmanian trees, and even *E. dives* yields a greater quantity of oil than does *E. amygdalina* of Tasmania. The oil of the Tasmanian

*E. amygdalina* differs from that of the New South Wales form in that it contains much less cineol, has a very high lævo-rotation, contains much more phellandrene, and is much less soluble in alcohol. The odour of the oil is also much less aromatic. The terpeneol in the oil of the Australian form is responsible for this more pronounced aromatic odour and greater solubility.

The following tabulated results give the general characters of the crude oils from three consignments, collected at the several localities, and on the dates given :—

|                                               | Hobart,<br>Tasmania,<br>16th April, 1912. | Nubeena, Tasman<br>Peninsula,<br>18th April, 1912. | Hobart,<br>Tasmania,<br>15th May, 1912. |
|-----------------------------------------------|-------------------------------------------|----------------------------------------------------|-----------------------------------------|
| Yield of oil ... ..                           | 1.64 per cent.                            | 2.04 per cent.                                     | 1.62 per cent.                          |
| Specific gravity at 15° C. ... ..             | 0.883                                     | 0.8668                                             | 0.8848                                  |
| Rotation $a_D$ ... ..                         | —75.1°                                    | —59.1°                                             | —67.3°                                  |
| Refractive index at 20° C. ... ..             | 1.4781                                    | 1.4767                                             | 1.4752                                  |
| Solubility in alcohol ... ..                  | 1 vol. 80 per cent.                       | 7 vol. 70 per cent.                                | 1 vol. 80 per cent.                     |
| Cineol ... ..                                 | 12 per cent.                              | 24 per cent.                                       | 16 per cent.                            |
| Saponification number for ester and free acid | 3.1                                       | 2.9                                                | 3.2                                     |

The cineol was determined by the resorcinol method, and although this would seem to indicate the presence of an increased amount of that constituent, yet a phosphoric acid determination in the mixed oils gave a result of 16 per cent. cineol.

The Nubeena sample contained less high-boiling constituents than did the Hobart material, and consequently had a lower specific gravity. It also contained more cineol.

On rectification, nothing distilled below 174° C. (corr.) with either sample. The Hobart (16th April, 1920), oil gave 57 per cent. distilling between 174–195° C., and 37 per cent. between 195–255°, mostly between 230–240°. The Hobart sample (15th May, 1912) gave 63 per cent. between 174–195°, and 32 per cent. between 195–245°. The Nubeena sample gave 83 per cent. distilling between 174–195°, and 10 per cent. between 195–266°. These fractions gave the following results :—

|                                   | Hobart,<br>16th April, 1912. | Hobart,<br>15th May, 1912. | Nubeena,<br>18th April, 1912. |
|-----------------------------------|------------------------------|----------------------------|-------------------------------|
| First Fractions—                  |                              |                            |                               |
| Specific gravity at 15° C. ... .. | 0.8589                       | 0.8662                     | 0.8605                        |
| Rotation $a_D$ ... ..             | —86.8°                       | —73.3°                     | —62.8°                        |
| Refractive index at 20° C ... ..  | 1.4729                       | 1.4728                     | 1.4748                        |
| Second Fractions—                 |                              |                            |                               |
| Specific gravity at 15° C. ... .. | 0.9191                       | 0.9184                     | 0.8939                        |
| Rotation $a_D$ ... ..             | —14.9°                       | —17.2°                     | —23.9°                        |
| Refractive index at 20° C. ... .. | 1.4828                       | 1.4814                     | 1.4821                        |

The high-boiling portions of these oils contained a considerable quantity of piperitone, as is the case with *E. dives*; thus the temperature did not rise much above 255° C.



Besides the above material sent by the Museum collector, we also received the leaves of the "Black Peppermint," from Scottsdale, Tasmania, forwarded by Mr. A. H. Higgs (6th March, 1912). This material gave a yield of oil equal to 2.32 per cent.

The crude oil had the following characters:—Specific gravity at 15° C. = 0.8765; rotation  $a_D$  — 42.9°; refractive index at 20° = 1.4796; soluble in 5 volumes 80 per cent. alcohol; had saponification number for esters and free acid = 2.9, and contained 20 per cent. cineol, by the resorcinol method.

On rectification, 80 per cent. distilled between 174–193° C., and 13 per cent. between 193–262°. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8599; rotation  $a_D$  — 53.2°; refractive index at 20° = 1.4770.

Second „ „ „ = 0.9092; rotation  $a_D$  — 7.1°; refractive index at 20° = 1.4927.

The oil distilled from the leaves of the "Black Peppermint" of Tasmania, *E. amygdalina*, from material all over the island, is thus seen to have considerable uniformity in composition.

The results of this investigation were published by us in the Proc Roy. Soc., Tasmania, October, 1912.

## 151. *Eucalyptus amygdalina*, var. *nitida*, Benth.

(B. Fl. iii, 203.)

**Systematic.**—The data given under *E. phellandra* applies in almost every particular to this species, so that no systematic description is required.

As the cineol content is very low, it is thought that for industrial as well as for scientific purposes, this variety had better be upheld.

So far it has only been collected by us at Blackheath, Katoomba, Mt. Victoria, in the Blue Mountains, and Lithgow, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were collected at Blackheath, N.S.W., in September, 1919. The yield of oil was 2.6 per cent. The crude oil was of a light lemon-yellow colour, and had an odour somewhat resembling that of the "narrow-leaf peppermint" of the ranges. The principal constituent was phellandrene, and pinene practically absent. Piperitone appears to be absent, or if present can only be so in traces. Cineol was detected in very small amount. Eudesmol was found by crystallisation, and geraniol was also shown to occur.

The crude oil had specific gravity at 15° C. = 0.8665; rotation  $a_D$  — 45.74°; refractive index at 20° = 1.4805, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 6.2, and in the cold with two hours' contact it was 3.9.

A portion was acetylated in the usual way; the saponification number for this acetylated oil was 40.7, and in the cold with two hours' contact, it was 22.7. Taking the free alcohols as consisting of eudesmol and geraniol only, this result shows that about 5.3 per cent. of geraniol, and 4.8 per cent. of eudesmol were present in the crude oil of this *Eucalypt*.



On rectification, 1 per cent. distilled below  $172^{\circ}$  C. (corr.). Between  $172-194^{\circ}$ , 88 per cent. distilled; between  $194-260^{\circ}$ , 6 per cent. came over, and between  $260-276^{\circ}$ , 4 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8561; rotation  $a_D - 51.5^{\circ}$ ; refractive index at  $20^{\circ} = 1.4792$ .  
 Second „ „ „ = 0.8904; rotation  $a_D - 28.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4850$ .  
 Third „ „ „ = 0.9406; rotation  $a_D + 9.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.5050$ .

The cineol was determined by the resorcinol method in the first fraction; a ketone absorption made in the same portion gave 2 per cent.; when corrected for the crude oil, the cineol present was only 5 per cent.

Material of this Eucalypt for distillation was forwarded from Guildford Junction, Tasmania, in September, 1912. The yield of oil was 0.6 per cent., which is considerably lower than from the New South Wales material. The oils, however, were practically identical in every way, and there is little doubt but that both were distilled from the same species. The chief constituent was phellandrene, and pinene probably absent. Cineol was detected, but in very small amount. Eudesmol was present, proved by crystallisation. It is doubtful if piperitone occurred, if so, it could only be in traces. Geraniol was detected as in the previous case.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.8628; rotation  $a_D - 57.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4833$ , and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.5.

A portion was acetylated in the usual manner; the saponification number for this acetylated oil was 33.6, and in the cold with two hours' contact, 22.1. Considering the free alcohols to consist of eudesmol and geraniol only, this result gives about 3 per cent. eudesmol and 6 per cent. geraniol.

On rectification, 1 per cent. distilled below  $172^{\circ}$  C. (corr.). Between  $172-193^{\circ}$ , 79 per cent. distilled; between  $193-255^{\circ}$ , 6 per cent. came over, and between  $255-275^{\circ}$ , 10 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8494; rotation  $a_D - 68.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.4786$ .  
 Second „ „ „ = 0.8878; rotation  $a_D - 28.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.4858$ .  
 Third „ „ „ = 0.9304; rotation  $a_D + 14.0^{\circ}$ ; refractive index at  $20^{\circ} = 1.5009$ .

The cineol was determined by the resorcinol method in the first fraction; when calculated for the crude oil, the result was only 1 per cent. A ketone determination with the first fraction gave negligible results.

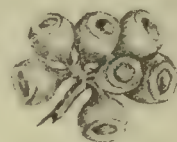
As illustrating the comparative constancy in results with the products of individual species, it may be mentioned that the above localities are over 600 miles apart.

## 152. *Eucalyptus phellandra*, sp. nov.

Narrow Leaf Peppermint.

**Systematic.**—A medium-sized tree, with a typical "Peppermint" bark. Abnormal leaves lanceolate, cordate, sessile, usually under 5 inches long and  $\frac{3}{4}$  inch broad, upper surface darker in colour, branchlets scabrous, particularly so when young. Normal leaves thin, lanceolate, or narrow lanceolate, sometimes falcate, up to 7 inches in length and 1 inch broad, on slender pedicels; venation distinct, intramarginal vein looped and well removed from the edge, a secondary less prominent vein often occurring nearer the margin, lateral veins very oblique, occasionally almost parallel to the mid-rib, distant and spreading. Peduncles usually axillary, 2 to 3 lines long, bearing umbels of ten or more flowers. Buds clavate; calyx tube tapering into a slender pedicel; operculum hemispherical, umbonate.

**Fruit.**—Pyriform, sometimes hemispherical, more or less shining, on a pedicel 1 line in length; rim reddish, truncate, somewhat counter-sunk or even slightly convex; valves not or only slightly exerted; 3 lines long and under 3 lines in diameter.



*E. amygdalina* of Tasmania is more likely than any other to be confounded with these fruits, and *E. Australiana* is its next in resemblance.

**Habitat.**—Barber's Creek, Batlow, Braidwood, Bundanoon, Bungendore, Burrawang, Crookwell, Hill Top, Laurel Hill, Lochiel, Marulan, Mittagong, Monga, Moss Vale, Tumberumba, Tumut, New South Wales; Warburton, Victoria.

**REMARKS.**—This species is one of the Eucalypts that has been included in the past under *E. amygdalina*, and its separation is the result of this research. Morphologically, it is difficult to distinguish from the type *E. amygdalina* and *E. Australiana*, both being long regarded as one species. The abnormal leaves are also similar to those of *E. viminalis*, and the same might be said of the normal leaves of the species above enumerated. The fruits more nearly resemble in shape those of *E. Australiana* than any other, and show a slight difference between those of that species and *E. amygdalina*. In the field it is classed as a "Peppermint" from the odour of the leaves and the nature of the bark. It is one of the few species of this research that has been founded almost entirely on the chemical constituents of the oil. The localities (supra) will help in some degree to systematically identify the tree. The economic importance of separating this species from *E. Australiana* can be judged from the fact that at the present time the value of the oil of the latter species is more than double that of *E. phellandra*.

**ESSENTIAL OIL.**—During the last twenty-five years, there have been distilled in Eastern Australia thousands of tons of oil from this Eucalyptus species. In New South Wales and Victoria, it occurs on the mountain ranges, growing in the former State at an altitude of about 1,500 to 3,000 feet. It has a most extensive range, particularly in southern New South Wales, and is especially abundant in the Braidwood district of this State.

The oil derived from this Eucalypt does not reach the standard laid down in the British Pharmacopœia, being deficient in cineol and containing too much phellandrene. It now finds its chief use in the mining industry for the separation of metallic sulphides by a flotation process. It is employed for this purpose equally with that of *E. dives*, and as the yield of oil is large it is a profitable species to work. It is also used for other manufacturing processes, mainly on account of its cheapness.



The general characters of the oil of this species are those recorded by us in the first edition of this work in 1902, under *E. amygdalina*. The results obtained at that time are reproduced below, and although since that book was published much work has naturally been undertaken with the oil of this species, yet we see no reason why the original statements should be modified, except perhaps that the cineol content might have been a little higher in all cases. The determinations were all made at that time by the phosphoric acid method, when it was considered necessary to press the cake repeatedly until absorption of oil ceased. Cineol determinations as thus made are now known to give too low results.

From the record of investigations with the oil of this *Eucalypt*, now extending over twenty years, it is evident that the general results are practically always in agreement, a fact which again illustrates the comparative constancy of the oil products of identical species.

The "Peppermint" group appears to be the most recent of the whole Genus, and for that reason might, perhaps, be considered as less stabilised than species belonging to the more ancient groups, yet even with the members of the "Peppermint" group, a similar constancy is observable.

**Analysis of the Oil.**—Leaves and terminal branchlets for distillation were obtained from Moss Vale, N.S.W., in March, 1899. The yield of oil was 4.2 per cent. The crude oil was but little coloured, and had a peppermint odour, but this was not so marked as was the case with the oil of *E. dives*. The secondary odour was aromatic, this being due to alcoholic bodies. A small quantity of eudesmol was detected, as it crystallised after the more volatile constituents had evaporated. Phellandrene was a constant constituent, and the amount present appears to be fairly uniform, but is much less abundant than in the oils of *E. dives* and *E. radiata*. Cineol was present to the extent of about 20 to 30 per cent. in the crude oil, but by a method of separation during the primary distillation an oil containing 40 to 50 per cent. of cineol can be obtained from this species. Pinene was present, but only in small amount; the physical and chemical properties for that terpene were, however, secured with the fraction obtained on completely rectifying the first distillate. Free alcohols were present in some quantity, as determined by acetylating the crude oil. The esters were very small in amount, and volatile aldehydes not at all pronounced.

The crude oil had specific gravity at 15° C. = 0.9026; rotation  $a_D$  — 10.3°; refractive index at 20° = 1.4703, and was soluble in 1¼ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 3.7.

On rectification, 1 per cent. distilled below 173° C. (corr.). Between 173–188°, 85 per cent. distilled, and between 188–215°, 10 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8987; rotation  $a_D$  — 10.3°.

Second " " " " = 0.9111; " "  $a_D$  — 9.0°.

The cineol, determined by the phosphoric acid method in the crude oil, was 22 per cent., and in the first fraction, 27 per cent. (O.M.).

The very high solubility for an oil containing that amount of cineol indicated that alcohols might be present; a portion of the crude oil was, therefore, acetylated in the usual way; the saponification number for this acetylated oil had then increased to 22.4.

Material of this species for distillation was also obtained from Monga, N.S.W., in July, 1898. The yield of oil at that time of the year was 3 per cent., but as this was the winter it was less abundant in the leaf, although richer in cineol. Similar constituents were present as in the Moss Vale oil, and on rectification the fractions were in agreement with those of the previous sample.



The specific gravity of the crude oil = 0.9012, and of the first fraction 0.8956. The optical rotation of the crude oil was  $a_D - 12.2^\circ$ , and of the first fraction  $a_D - 13.6^\circ$ . The cineol in the crude oil determined by the phosphoric acid method was 32 per cent. (O.M.). The crude oil was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol, as in the previous case.

As illustrating the general characters of commercially distilled oils of this species, the following list is given. There was no doubt as to the authenticity of these samples as submitted to us.

The localities represent a considerable area of country. They were all crude oils, and the cineol was determined by the phosphoric acid method.

| Locality and Date.             | Sp. gr.<br>at 15° C. | Ref. ind.<br>at 20° C. | Optical<br>rotation<br>$a_D$ | Solubility,<br>70 per cent.<br>alcohol. | Cineol,<br>per cent. | Month when<br>distilled.   |
|--------------------------------|----------------------|------------------------|------------------------------|-----------------------------------------|----------------------|----------------------------|
| Glengarry, N.S.W., 1907 ...    | 0.9082               | .....                  | $-7.1^\circ$                 | $1\frac{1}{2}$ vols.                    | 38                   | July.<br>(Mid-<br>winter.) |
| Laurel Hill, N.S.W., 1908 ...  | 0.9078               | .....                  | $-9.2^\circ$                 | $1\frac{3}{4}$ vols.                    | 30                   | April.                     |
| Braidwood, N.S.W., 1912 ...    | 0.9023               | 1.4689                 | $-13.7^\circ$                | $1\frac{3}{4}$ vols.                    | 30                   | Sept.                      |
| Yarra Junction, Vic., 1911 ... | 0.9057               | 1.4710                 | $-22.2^\circ$                | $2\frac{1}{2}$ vols.                    | 25                   | Feb.                       |
| W. Kangaloon, N.S.W., 1912     | 0.9116               | 1.4658                 | $-6.1^\circ$                 | $1\frac{1}{2}$ vols.                    | 40                   | June.<br>(Mid-<br>winter.) |
| Monga, N.S.W., 1912 ...        | 0.8948               | 1.4683                 | $-17.1^\circ$                | 3 vols.                                 | 28                   | April.                     |
| Araluen, N.S.W., 1912 ...      | 0.9060               | 1.4681                 | $-13.1^\circ$                | $1\frac{1}{2}$ vols.                    | 39                   | Aug.                       |

As the yield of oil from this species was so large, it was thought desirable to undertake experiments in order to determine whether an oil richer in cineol could be obtained by distilling the leaves in a special manner. We were indebted to the Australian Eucalyptus Oil Company, of Sydney, for assistance in deciding this question. This company was distilling oil from this species at Moss Vale, N.S.W., and the product from one tank was collected for us, by separating the whole of the oil that came over during the first, second, and third hours of distillation respectively. The ordinary square 400-gallon iron-tank, so extensively used in this industry, was employed for the purpose. It was at once seen that the oil which came over during the first hour was much richer in cineol than either that of the second or third hours. The quantitative determinations of the cineol were all made by the phosphoric acid method, and consequently are a little lower than the true content, although comparative.

*First-hour Oil.* Specific gravity = 0.9126; optical rotation  $a_D - 9.2^\circ$ ; cineol = 38 per cent. (O.M.).

*Second-hour Oil.* Specific gravity = 0.902; optical rotation  $a_D - 12.5^\circ$ ; cineol = 15 per cent. (O.M.).

*Third-hour Oil.* Specific gravity = 0.898; optical rotation  $a_D - 21.0^\circ$ ; cineol was present in very small quantity.

Phellandrene was present in all three samples, but was more pronounced in the oil distilling during the second and third hours.

A consignment of the commercially distilled crude oil from this species, containing the whole of the oil obtainable from the leaf, gave the following results:—Specific gravity = 0.905; optical rotation  $a_D - 11.3^\circ$ ; cineol = 27 per cent. (O.M.).

The above results were such that it was thought advisable to carry the experiments further. A tank was specially prepared for us by the Company, and the oil distilling during the several hours kept separate. The oil was distilled in April, 1899. The weight of leaves taken, collected as for commercial oil distillation, was 320 lbs. The weight of the whole oil obtained was  $11\frac{1}{4}$  lbs., equal to 3.5 per cent. Of this 8 lbs. came over during the first hour = 71 per cent.; 2 lbs. during the second hour = 18 per cent.; 12 ozs. during the third hour = 7 per cent., and 7 ozs. during the fourth hour = 4 per cent.

The greater portion of the cineol came over during the first hour, the oil collected during that period containing more than 30 per cent. of that constituent. The second hour oil contained considerably less cineol, and had a secondary odour suggesting citral. Only a very small quantity of cineol was found in the third-hour oil, and it could hardly be detected in the fourth-hour oil.

In June, 1899, a second investigation was undertaken, 400 lbs. of leaves and terminal branchlets being distilled, from which 14 lbs. of oil were obtained, equal to 3.5 per cent. Of this 9 lbs. came over during the first hour = 64 per cent.;  $3\frac{1}{2}$  lbs. during the second hour = 25 per cent.; 1 lb. during the third hour = 7 per cent., and 8 ozs. during the fourth hour = 4 per cent.

The greater portion of the cineol in the oil came over during the first hour; a considerably less amount during the second hour; a very small quantity during the third hour, and only a trace could be detected in the fourth hour oil.

Other determinations were made in June and July of the same year, but as the results were quite concordant, it is unnecessary to tabulate the figures.

The above investigations resulted eventually in the oil of *E. Australiana* being distilled commercially in this way, and the "first-hour oil" from that species was placed on the market as such, and sold as a first-class pharmaceutical Eucalyptus oil, the product which came over later being utilised for other purposes. (See under that species in this work.)

It was thus shown that by collecting apart the product distilling during the first hour, the greater portion of the cineol in the oil was obtained in this way. It was possible to still further enrich it by fractionation, collecting apart the portion distilling below  $175^{\circ}$  C. (uncorr.), discarding the fraction containing the volatile aldehydes. The product obtained in this way from the mixed first and second hour oils gave the following results:—Specific gravity = 0.896; optical rotation  $a_D$  —  $10.4^{\circ}$ ; cineol = 43 per cent. (O.M.).

The oil as thus obtained was water-white, of a pleasant aromatic odour, and although containing phellandrene, yet that constituent was not present in excessive amount. It is thus seen that the oil from this Eucalypt is distinctly different from that obtainable from either *E. dives* or *E. radiata*, which species supplied much of the oil sent to Europe at one time under the name of *E. amygdalina*.

We visited one of the districts of this State, where Eucalyptus oil was, at that time (1899) distilled, and saw evidences that the material being worked in that locality was obtained principally from *E. dives*, some from *E. radiata*, as well as from the present species. Large quantities of the "suckers" of *E. dives* were growing up in all directions, and were springing from the stumps of the trees that had been originally cut down for Eucalyptus oil distillation. Much of this oil was forwarded to Europe as the product of *E. amygdalina*. At that time *E. dives*, *E. radiata*, and others that are now recognised as distinct species, were all classified by some botanists as varieties of the one species (*E. amygdalina*), and it appeared difficult to discriminate between them by the then recognised methods of classification. The chemical investigation of their several products had not at that time been separately carried out, so that this aid towards correct



classification was not then available. Chemical investigation demonstrated that the morphological differences which marked these species were specific, and that the "Peppermint" tree, *E. piperita*, had even more chemical affinity to the present species than had either *E. dives* or *E. radiata*.

It would not be possible for a mixed oil from these three species (*E. radiata*, *E. dives*, and *E. phellandra*) to give even comparatively constant physical or chemical results, so that if examined at different times and by different observers, little agreement would be shown as existing in the supposed product from one particular species. To illustrate the necessity of keeping the products from distinct species apart, we have tabulated the results obtained with these three species from different localities.

These oils all contained phellandrene in varying amounts, and it is to the presence of that terpene that the lævo-rotation of the oil is largely due.

| Species and Localities.            |     |     |     | Specific gravity at 15° C. Crude oil. | Optical rotation, $\alpha_D$ Crude oil. | Yield per cent. |                                                             |
|------------------------------------|-----|-----|-----|---------------------------------------|-----------------------------------------|-----------------|-------------------------------------------------------------|
| <i>E. dives</i> —                  |     |     |     |                                       |                                         |                 |                                                             |
| Berrima, 10-5-99                   | ... | ... | ... | 0.8887                                | —55.7°                                  | 2.89            | Cineol was in very small amount. Piperitone was pronounced. |
| <i>E. dives</i> *—                 |     |     |     |                                       |                                         |                 |                                                             |
| Fagan's Creek, Braidwood, 20-10-98 | ... | ... | ... | 0.8820                                | —63.9°                                  | 1.96            | " "                                                         |
| <i>E. dives</i> *—                 |     |     |     |                                       |                                         |                 |                                                             |
| Barber's Creek, 24-10-98           | ... | ... | ... | 0.8820                                | —63.6°                                  | 2.04            | " "                                                         |
| <i>E. dives</i> —                  |     |     |     |                                       |                                         |                 |                                                             |
| Rylstone, 25-8-98                  | ... | ... | ... | 0.8713                                | —62.2°                                  | 2.09            | " "                                                         |
| <i>E. radiata</i> —                |     |     |     |                                       |                                         |                 |                                                             |
| Monga, 6-9-98                      | ... | ... | ... | 0.8747                                | —65.1°                                  | 1.88            | Piperitone was less pronounced.                             |
| <i>E. radiata</i> —                |     |     |     |                                       |                                         |                 |                                                             |
| Wingello, 11-9-1900                | ... | ... | ... | 0.8695                                | —77.7°                                  | 1.2             | " "                                                         |
| <i>E. phellandra</i> —             |     |     |     |                                       |                                         |                 |                                                             |
| Moss Vale, 1-3-99                  | ... | ... | ... | 0.9026                                | —10.3°                                  | 4.2             | Cineol, crude oil, 22 per cent. (O.M.)                      |
| <i>E. phellandra</i> —             |     |     |     |                                       |                                         |                 |                                                             |
| Monga, 21-7-98                     | ... | ... | ... | 0.9012                                | —12.2°                                  | 3.0             | Cineol, crude oil, 32 per cent. (O.M.)                      |

\* Note the marked agreement between these two samples of oil of *E. dives*, although obtained from widely separated localities. This is due to the time of the year being the same in both instances.

It may be assumed that during the spring and summer months, the optical rotation of a particular Eucalyptus oil will be somewhat greater than during the winter months, owing to the presence at that time of an increased amount of the particular terpene causing the rotation; on the other hand, the cineol is generally more pronounced during the winter months.

It is evident that an oil rich in cineol could not be obtained from either *E. dives* or *E. radiata*. On the other hand the peppermint ketone, piperitone, which is such a pronounced constituent in the oil of *E. dives*, could not be profitably extracted from the oils of either *E. radiata* or the present species.

The great differences of solubility in alcohol between the oils of the above three species is also worthy of notice.



## 153. *Eucalyptus vitrea*.

(R.T.B. Proc. Linn. Soc., N.S.W., 1900, p. 1:3, t. XV.)

### White Top Messmate.

**Systematic.**—A tall tree, with a roughish bark, similar to *E. amygdalina*, Labill., the extremities of the branches being smooth. Abnormal leaves alternate or opposite, with a short petiole, or sessile, ovate-lanceolate, acuminate, under 6 inches long,  $1\frac{1}{2}$  inch broad; lateral veins diverging from below the middle of the mid-rib, prominent on both sides, intramarginal vein removed from the edge. Normal leaves narrow, lanceolate, about 6 inches long, and 6 to 9 lines wide, shining on both sides, a dull green when fresh, but drying a light-slate colour, petiole short; lateral veins few, and almost parallel to the mid-rib, two generally commencing at the base of the mid-rib, and running the whole length of the leaf, and almost parallel to the mid-rib. Peduncles axillary, short, 2 to 3 lines long, bearing generally from five to eight flowers; buds from  $2\frac{1}{2}$  to 4 lines long; operculum hemispherical, shortly acuminate.

**Fruit.**—Shortly pedicellate, hemispherical to pyriform, shining; rim thick, red, slightly convex; about 3 to 5 lines in diameter, and 3 to 5 lines in length.



*The hemispherical form much resembles E. dives, but is larger, and the pyriform shape is like E. coriacea.*

**Habitat.**—Crookwell, Moss Vale, mountains north of Marulan, Bungendore, and Delegate, New South Wales; Victoria.

**REMARKS.**—This tree is also known locally as "Silver-top Messmate," "Peppermint," and "Messmate"; but in connection with this species it is not proposed to perpetuate the two latter vernacular names, which should be, we think, restricted to *E. dives*, Schau., and *E. phellandra*, respectively. It is called "Silver-top" from the glinting of the shining leaves in the sunlight, which causes them to appear silvery. For a similar reason *E. lavopinea*, R.T.B., is called "Silver-top Stringybark." In the South it is known as "Bastard Messmate." This tree has been confounded with *E. coriacea*, A. Cunn., when determined on herbarium material alone. In the field, however, its willowy appearance differentiates it from *E. coriacea*. This tree has either a roughish "Messmate" or smooth bark, and always clean or white limbs, and a leaf venation similar to that of *E. coriacea*, and more particularly perhaps that of *E. stellulata*, Sieb. The term "White-top" is, no doubt, used to distinguish it from the "Messmate," *E. phellandra*, not that the leaves are white, but only, as stated above, appear so from the reflected light of the sun from the glossy surface of the leaves, and from which feature it takes its specific name.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Crookwell, N.S.W., in June, 1900. The yield of oil was 1.5 per cent. The crude oil was almost colourless, and had a somewhat pleasant peppermint odour, although the ketone piperitone does not occur in great amount. Phellandrene was present in quantity, but pinene almost absent. Cineol was detected to the extent of about 20 to 25 per cent. in the crude oil. The third fraction contained the sesquiterpene. A constituent having a strong lemon odour was also present; this was probably citral, as the aldehyde reaction was obtained, but it was not in sufficient quantity to separate.

The crude oil had specific gravity at  $15^{\circ}\text{C.} = 0.886$ ; rotation  $a_D = -30.1^{\circ}$ ; refractive index at  $20^{\circ} = 1.4771$ , and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 5.4.

On rectification, 2 per cent. distilled below  $173^{\circ}$  C. (corr.). Between  $173$ – $183^{\circ}$ , 76 per cent. distilled; between  $183$ – $224^{\circ}$ , 14 per cent. came over, and between  $224$ – $270^{\circ}$ , 4 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8792; rotation  $a_D$  —  $33.2^{\circ}$ .

Second „ „ „ = 0.8940; „ —  $45^{\circ}$ .

Third „ „ „ = 0.9256; „ not taken.

The cineol, determined by the phosphoric acid method in the first fraction, was 26 per cent. (O.M.), indicating about 20 per cent. in the crude oil. When determined nineteen years later by the rapid phosphoric acid method, the result was 22 per cent. in the crude oil, this having been stored in the dark during that time.

## 154. *Eucalyptus Luehmanniana*.

(F.v.M., in Frag., xi, 38.)

**Systematic.**—A small tree, or ‘ Mallee,’ with a flaky bark towards the butt of the trunk, upper limbs smooth, branchlets distinctly quadrangular, or flattened and glaucous, as well as the buds and peduncles. Leaves coriaceous, variable in size, those in the early growth of timber broadly lanceolate, 3 inches wide to 7 inches long, ordinary ones lanceolate, about 6 inches long and 1 inch wide, green on both sides, slightly shining, petiole flattened, over 1 inch long; venation very pronounced, lateral veins oblique, spreading, intramarginal ones removed from the edge. Peduncles axillary, much flattened, sometimes 6 lines broad at the top, bearing about six flowers, which in the early stage of growth are enclosed in a calyptra or bracts. Calyx and pedicel continuous, almost quadrangular wrinkles much in drying, about 2 to 3 lines in diameter when in flower; operculum acuminate under 3 lines long.

**Fruit.**—Hemispherical, shining, ribbed, on a very stout flat peduncle about 1 inch long and 3 lines broad; rim broad, outer edge raised in a thin circle; valves inserted, 6 lines in diameter.

*This fruit stands alone, being quite distinct from any described Eucalypt.*



**Habitat.**—National Park, Bulli Mountain, Spit, Port Jackson, Balgowlah, New South Wales.

**REMARKS.**—This tree is very rare in New South Wales, being only recorded from a few localities in the neighbourhood of Sydney. Mueller was the original author of this species, but he afterwards synonymised it under *E. stricta*, with which species it does not appear to us to have any morphological affinity, as the two seem quite distinct. We think that this *Eucalyptus* from the above quoted localities is distinct from any other New South Wales *Eucalyptus* tree, and so have retained Mueller's original name for it, as it should, in our opinion, and in the light of our researches, now stand as a species. We do not see how it can be *E. virgata*, Sieb., as all the previous writings on that particular species go to show that in herbarium material *E. virgata*, of Sieber, so much resembled *E. Sieberiana* of Mueller, that the two were thought to be almost, if not quite, identical, and so were placed under one name by Benthams, B. Fl., vol. iii, p. 202. The herbarium material of *E. Luehmanniana* cannot be confounded with any known species as far as we know, as it is so characteristic. (Vide also remarks under *E. virgata*, Sieb., and *E. Sieberiana*, F.v.M., in this work.)



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from National Park N.S.W., in September, 1900. The yield of oil was 0.3 per cent. The crude oil was light amber in colour, and had a peppermint odour due to the presence of a small quantity of piperitone. It contained a large quantity of phellandrene, but only a small amount of pinene. Cineol was present, but not more than about 10 per cent. in the first fraction. A lemon odour was detected in the portion distilling at about 230° C., so that probably citral occurs in the oil, especially as the presence of a high-boiling aldehyde was shown. Esters were only present in very small amount. Eudesmol was detected, as it crystallised after the more volatile constituents had evaporated.

The crude oil had specific gravity at 15° C. = 0.879; rotation  $a_D$  — 27.5°; refractive index at 20° = 1.4880, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.3.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–183° 75 per cent. distilled; between 183–224°, 13 per cent. came over, and between 224–278°, 6 per cent. distilled. These fractions gave the following results :—

|                                  |                             |                         |
|----------------------------------|-----------------------------|-------------------------|
| First fraction,                  | sp. gr. at 15° C. = 0.8719; | rotation $a_D$ — 30.2°. |
| Second    ,,        ,,        ,, | = 0.8885;                   | ,, $a_D$ — 22.7°.       |
| Third     ,,        ,,        ,, | = 0.9237;                   | ,,    not taken.        |

## 155. *Eucalyptus coccifera*.

(Hook., f., in Lond. Journ. Bot., vi, 477, 1847.)

**Systematic.**—A small tree, generally very glaucous, with a smooth white bark. Abnormal leaves opposite, sessile or shortly petiolate, oval, rarely obovate, mucronate, about 1 inch long. Normal leaves lanceolate or narrow elliptical, usually acuminate, uncinat, thick and shining, 2 to 3 inches long; venation not prominent, intramarginal vein well removed from the edge, lateral veins oblique. Flowers sessile, from three to six on axillary or lateral peduncles, thick, flattened upwards, 2 to 4 lines long. Calyx tube prominently angled, tapering to base, 3 lines long; operculum very short, flat or depressed rugose.

**Fruit.**—Broad, turbinate, sometimes conoidal; rim broad, flat or somewhat domed; valves scarcely exerted; 5 lines long and 6 lines in diameter.

*These fruits are fairly characteristic, perhaps the nearest in shape are those of E. hæmastoma, that is the pedicellate form. The sessile fruits are near perhaps to those of E. St. Johni, except that this rim is nearly flat.*



**Habitat.**—Confined to Tasmania, at high elevations.

**REMARKS.**—It is generally recorded as one of the few endemic Eucalypts of Tasmania, and as it only occurs near or on the snow-line, does not assume large proportions, consequently its economics are limited.



**ESSENTIAL OIL.**—Material for distillation was obtained from Mt. Wellington, Tasmania, at an altitude of about 4,000 feet. It was collected in July, 1908. The principal constituent in the oil of this species was phellandrene, and pinene practically absent. Cineol was present only in small amount, probably not more than 5 per cent. in the first fraction. Traces of eudesmol were detected when the oil was first distilled. The oil also contained a small amount of piperitone, and thus belongs to the "Peppermint" group of these oils, of which *E. dives* may be considered the type. The chemical results show *E. coccifera* to be very closely related to *E. coriacea*; the yield of oil is somewhat small for a phellandrene-bearing Eucalypt, consequently *E. coccifera* has no commercial value as an oil-producing tree.

The yield of oil from the leaves and terminal branchlets was 0.61 per cent. The crude oil was of an amber colour. It had specific gravity at 15° C. = 0.8810; rotation  $a_D$  — 35.8°; refractive index at 20° C. = 1.4849, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was only 4.9.

On rectification, a small quantity of acid water and volatile aldehydes came over below 170° C. (corr.). Between 170–183° 69 per cent. distilled; between 183–235°, 5 per cent., and between 235–278°, 20 per cent. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8561; rotation  $a_D$  — 43.4°; refractive index at 20° = 1.4791.

Second    ,,        ,,        ,,        = 0.8705; rotation  $a_D$  — 25.2°; refractive index at 20° = 1.4831.

Third     ,,        ,,        ,,        = 0.9199; rotation not taken; refractive index at 20° = 1.4970.

The high-boiling fraction consisted largely of the sesquiterpene together with eudesmol.

The results of this investigation were published by us in the Proc. Roy Soc., Tasmania, October, 1912.

## GROUP VII.

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CLASS (b).

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In this Group are placed the following EUCALYPTS yielding an oil consisting largely of phellandrene and piperitone, but in which cineol is almost, if not quite, absent:—

- |      |                   |                       |
|------|-------------------|-----------------------|
| 156. | <i>Eucalyptus</i> | <i>coriacea.</i>      |
| 157. | <i>E.</i>         | <i>Sieberiana.</i>    |
| 158. | <i>E.</i>         | <i>campanulata.</i>   |
| 159. | <i>E.</i>         | <i>oreades.</i>       |
| 160. | <i>E.</i>         | <i>Delegatensis.</i>  |
| 161. | <i>E.</i>         | <i>regnans.</i>       |
| 162. | <i>E.</i>         | <i>gomphocephala.</i> |
| 163. | <i>E.</i>         | <i>tæniola.</i>       |
| 164. | <i>E.</i>         | <i>Andrewsi.</i>      |
| 165. | <i>E.</i>         | <i>dives.</i>         |
| 166. | <i>E.</i>         | <i>radiata.</i>       |
-

## 156. *Eucalyptus coriacea*.

(A. Cunn., Schau., in Walp. Rep., ii, 925.)

(Syn. *E. pauciflora*, Sieb.)

**Cabbage or White Gum.**

**Systematic.**—A tall tree in favourable situations, but is found in a dwarf form on Mount Kosciusko, Snowy Mountains, N.S.W. Bark clean, white, and smooth, hence called "White Gum." Leaves lanceolate, comparatively large, thick, acuminate into a recurved point, falcate, sometimes over 9 inches long and  $1\frac{1}{2}$  inch wide; venation often obscured, lateral veins very oblique and almost parallel to the mid-rib, giving the leaf a several-nerved appearance. Peduncles axillary, varying in length up to 6 lines, flattened or terete, bearing few flowers, shortly pedicellate or sessile. Calyx 3 lines long, pear-shaped; operculum hemispherical, depressed or conical, but obtuse.

**Fruit.**—Pear-shaped, contracted at the rim, which is either broad and truncate, or thin and countersunk; valves not exerted; 4 to 6 lines in diameter.



*These fruits resemble those of E. vitrea, and also E. ovata.*

**Habitat.**—Coast district, but chiefly on the Tableland, New South Wales. This (strictly speaking) mountain species extends from the New England Ranges into Victoria and South Australia.

**REMARKS.**—It has a clean white stem, and is conspicuous in the landscape. The thick leathery leaves, fruit, and timber differentiate it from *E. stellulata*, Sieb., *E. vitrea*, R.T.B., &c., species having a somewhat similar venation. The timber is hard, pale-coloured, but seasons badly, and is little valued, being subject to gum veins.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Ilford, N.S.W., in July, 1898. The yield of oil was 0.45 per cent. The crude oil was light yellowish-brown in colour, and had a peppermint odour, due to the presence of a small quantity of piperitone. Much phellandrene was present, *but pinene only in small amount*. A very small quantity of cineol was detected in the first fraction. The higher-boiling portion consisted largely of the sesquiterpene, together with eudesmol. Esters were not pronounced. The oil of this species differs greatly from that of *E. phlebophylla*, a species which has botanical features similar to those of *E. coriacea*.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.8947; rotation  $a_D - 29.3^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4845, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 4.6.

On rectification, 1 per cent. distilled below  $174^{\circ}$  C. (corr.). Between  $174-188^{\circ}$ , 63 per cent. distilled; between  $188-204^{\circ}$ , 13 per cent. came over, and between  $204-280^{\circ}$ , 19 per cent. distilled. These fractions gave the following results:—

|                 |                            |           |                                 |
|-----------------|----------------------------|-----------|---------------------------------|
| First fraction, | sp. gr. at $15^{\circ}$ C. | = 0.8676; | rotation $a_D - 30.3^{\circ}$ . |
| Second          | "                          | = 0.8750; | " not taken.                    |
| Third           | "                          | = 0.9380; | " not taken.                    |



The above sample was stored in the dark, and in November, 1919, was again analysed. Not much alteration had taken place during the twenty-one years it had been kept, except that the rotation with the crude oil had diminished considerably. This was apparently due to the alteration in optical rotation of the piperitone, as the phellandrene had not altered much. This is shown by the fact that while the loss in rotation with the crude oil was  $21.5^{\circ}$ , that with the rectified portion was only  $2.1^{\circ}$ . 62 per cent. distilled below  $190^{\circ}\text{C}$ . The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}\text{C}$ . = 0.8996; rotation  $a_D$  —  $7.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4856.

Rectified portion „ = 0.8693; rotation  $a_D$  —  $28.2^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4776.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 10 per cent. As piperitone was present, a ketone determination was made in the rectified portion, with the result that 6 per cent. was absorbed. Thus about 5 per cent. of cineol was present in the crude oil.

Material for distillation was obtained in March, 1913, from Mount Kosciusko, N.S.W., the highest point in Australia, where the tree is known as the "Snow Gum." The yield of oil was 0.76 per cent.

The crude oil had a peppermint-like odour, due to the presence of piperitone. Phellandrene was pronounced and pinene practically absent. Cineol was present in very small amount, and crystallised eudesmol was also detected. The high-boiling portion consisted largely of the sesquiterpene.

Altogether this oil had strong resemblance to that originally distilled from the material collected at Ilford in 1898.

The crude oil had specific gravity at  $15^{\circ}\text{C}$ . = 0.8983; rotation  $a_D$  —  $27.0^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4890, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 3.7.

The cineol was determined by the resorcinol method in the portion distilling below  $190^{\circ}\text{C}$ .; when calculated for the crude oil, the result was 5 per cent.

## 157. *Eucalyptus Sieberiana*.

(F.v.M., in *Eucalyptographia*, Dec., ii, 1879.)

Mountain Ash.

**Systematic.**—A tall tree with a dark, fibrous, deeply-furrowed bark. Abnormal leaves oblique, ovate, shortly acuminate, and about 3 inches long, or lanceolate-falcate, over 6 inches long; venation distinct, lateral veins very oblique, spreading, distinct, the intramarginal vein removed from the edge. Normal leaves lanceolate, falcate, coriaceous, shining, or lustreless; venation fairly prominent, and similar to that of abnormal leaves. Flowers on axillary,

compressed peduncles, 9 lines long, with not many in the umbel. Calyx very short, on a pedicel of about 3 lines long; operculum hemispherical, sometimes with a point.

**Fruit.**—Pear-shaped, slightly contracted at the edge; rim red, flat, thick; valves compressed; mostly about 6 lines long and 3 lines in diameter.



*The fruits of two or three others are difficult to separate from this species, viz.:—E. Consideniana, E. campanulata, E. virgata.*

**Habitat.**—Blue Mountains and Coast district of New South Wales; South Australia; Victoria; Tasmania, where it is known as "Ironbark."

**REMARKS.**—Bentham (B. Fl., iii, p. 202) evidently includes this Eucalyptus under Sieber's *E. virgata*, but Mueller, thinking Sieber's name inappropriate for so large a tree, suppresses Sieber's name of *E. virgata*, and renames his specimens, dedicating the tree to Sieber. The tree, as now understood, is one of the "Mountain Ashes" of the Blue Mountains. The bark is similar to that of an "Ironbark," and extends almost to the branchlets, which are always of a purple colour. The very greatest care is required in order not to confound this species with a "Mallee" that is found on the Blue Mountains and other localities, and which has exactly identical foliage and fruits, and cannot, therefore, be differentiated from it by dried specimens. We think this latter is *E. virgata* of Sieber, who would never have applied such a name to so large a tree as *E. Sieberiana*, and Mueller must have suspected that Sieber referred "to a different species" other than this "Mountain Ash," by a remark of his in his Eucalyptographia, under *E. Sieberiana*. Morphologically, the two cannot be separated, and hence the confusion of Bentham, Woolls, and others in the matter of these two species. Judged, however, from field observations and chemical results the two are quite distinct, and are so regarded in this work. (*Vide* remarks under *E. virgata*.)

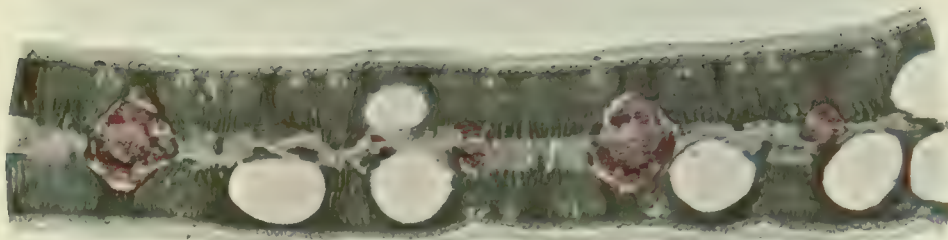
**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Barber's Creek, N.S.W., in April, 1898. The yield of oil was 0.5 per cent. The crude oil was but little-coloured, and had a peppermint odour, due to the presence of a small quantity of piperitone. It had a strong resemblance to the other oils of this class, such as *E. dives*, *E. coriacea*, *E. radiata*, &c. The venation of the leaves is also similar to those of the members of this group. Much phellandrene was present, but pinene only in small amount. Cineol could be detected in the first fraction, but not more than 5 to 10 per cent. Crystallised eudesmol was not detected, nor did the oil distilled from this species in September, 1899, contain that constituent. This latter material was obtained specially for the purpose of deciding this point, as we were then investigating the oil of *E. virgata*. Esters were very small in amount. Cymene probably occurs in this oil.

The crude oil had specific gravity at 15° C. = 0.8880; rotation  $a_D$  — 43.3°; refractive index at 20° = 1.4829, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.5.

On rectification, 2 per cent. distilled below 175° C. (corr.). Between 175–188°, 56 per cent. distilled; between 188–205°, 12 per cent. came over, and between 205–266°, 22 per cent. distilled. The third fraction consisted largely of the sesquiterpene. The fractions gave the following results:—

|                             |                             |                         |
|-----------------------------|-----------------------------|-------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8675; | rotation $a_D$ — 52.4°. |
| Second     ,,     ,,     ,, | = 0.8815;                   | rotation $a_D$ — 39.5°. |
| Third     ,,     ,,     ,,  | = 0.9382;                   | rotation not taken.     |

Material of this species for distillation was also obtained from the same locality in September, 1899. With the exception that the yield of oil was lower, and the lævo-rotation a little less (both factors being due to the difference in the time of the year), it was practically identical with the previous sample, and consisted of the same constituents in practically the same amounts.



Leaf of  
*Eucalyptus*

This section shows a rather unusual number of oil glands for a species with a comparatively low yield of oil. It is, however, a very evenly balanced leaf structurally, the mesophyll in the centre supported top and bottom by equal palisade tissue, and the cuticle particularly well developed towards either surface. The oil glands are very rarely found to run across from side to side, but are confined to either half of the leaf.

X 55.

*EUCALYPTUS SIEBERIANA*, F.v.M.



70 VIII  
ANNUAL

The above two samples were mixed and stored in the dark, and in November, 1919, the oil was again analysed. Very little alteration had taken place in the oil during the twenty years it had been kept, with the exception that the optical rotation had been reduced by about 10 degrees. This appears to be due to the alteration of the phellandrene, as the loss was about the same in both the crude oil and in the rectified portion. 53 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

|                              |           |                         |                         |
|------------------------------|-----------|-------------------------|-------------------------|
| Crude oil, sp. gr. at 15° C. | = 0.8970; | rotation $a_D$ — 33.4°; | refractive index        |
|                              |           | at 20° = 1.4827.        |                         |
| Rectified portion            | „         | = 0.8696;               | rotation $a_D$ — 43.6°; |
|                              |           | at 20° = 1.4753.        | refractive index        |

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 17 per cent. As piperitone was present, a ketone determination was made in the rectified portion, with the result that 10 per cent. was absorbed, so that about 11 per cent. of cineol was present in the crude oil.

## 158. *Eucalyptus campanulata*.

(R.T.B. & H.G.S., Proc. Roy. Soc., N.S.W., 1911, p. 288.)

### A Stringybark.

**Systematic.**—An average forest tree, with a stringybark, persistent on the trunk, branches smooth. Abnormal leaves broad-lanceolate, oblique, not shining, alternately petiolate, often over 9 inches long. Normal leaves lanceolate, oblique, falcate, acuminate, sub-coriaceous, about 4 inches long; venation not prominent on the upper side, intramarginal vein well removed from the edge, lateral veins very oblique. Umbels with about six flowers, usually axillary, peduncles 6 lines long, angular, sometimes flattened. Buds clavate, tapering to pedicels about 2 lines long; operculum domed, sometimes shortly pointed.

**Fruit.**—Oblique, campanulate in early stages, mature fruit pyriform; rim truncate or slightly countersunk; valves scarcely exerted; 2 to 3 lines long and 2 lines wide.



*The fruits mostly resembling these are those of E. virgata or E. Sieberiana.*

**Habitat.**—Tenterfield, Upper Williams River, New South Wales.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Tenterfield in January, 1910. The material was collected as for commercial distillation, so that the yield is an average one. The crude oil was of a light-yellowish tint, and had a secondary odour of peppermint, due to the presence of a small quantity of piperitone. The occurrence of this constituent, and the absence of the aldehyde aromadendral, distinguishes the oil of this species from that of *E. obliqua*. The oil consisted principally of phellandrene, and pinene was practically absent. Cineol was detected in the portion distilling at about 176° C., but it was very small in amount. A small quantity of crystallised eudesmol was also present. The oil of this species agrees with those of the

members of the "Mountain Ash" group of Eucalypts, but in its general characters more closely approaches, perhaps, that of *E. oreades* than any of the others. The following results were obtained with the crude oil :—

|                            |     |     |     |     |          |
|----------------------------|-----|-----|-----|-----|----------|
| Yield of oil per cent.     | ... | ... | ... | ... | 0.85.    |
| Specific gravity at 15° C. | ... | ... | ... | ... | 0.8804.  |
| Rotation $a_D$             | ... | ... | ... | ... | — 25.8°. |
| Refractive index at 20° C. | ... | ... | ... | ... | 1.4847.  |

Scarcely soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 7.6.

On rectification, 1 per cent. distilled below 175° C. (corr.). Between 175–188°, 68 per cent. distilled; between 188–224°, 11 per cent. came over, and between 224–265°, 11 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at 15° C. = 0.8589; rotation  $a_D$  — 34.8°; refractive index at 20° = 1.4803.

Second „ „ „ = 0.8714; rotation  $a_D$  — 32.6°; refractive index at 20° = 1.4826.

Third „ „ „ = 0.9224; rotation not taken; refractive index at 20° = 1.4980.

The phellandrene in the oil of this species has a less lævo-rotation than is the case with such species as *E. dives*, *E. radiata*, &c., so that the influence of the dextro-rotatory modification is assumed.

The results obtained with the oil of this species were published by us in the Proc. Roy. Soc., N.S.W., November, 1911.

PLATE LXXIII.



EUCALYPTUS OREADES, R.T.B.

Rocky Towers, Hazelbrook, New South Wales.



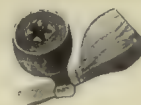
## 159. *Eucalyptus oreades*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1899, p. 596, t. XLIII.)

### A Mountain Ash.

**Systematic.**—A tall tree, with a smooth, whitish bark, or sometimes having a slightly rough bark 6 to 8 feet from the ground. Abnormal leaves thin, elliptical-oval, shortly acuminate, on a petiole of about 1 inch or more, venation more distinct than on mature leaves. Normal leaves long, often measuring 9 inches, thick, shining, dark green on both sides, on rather long petioles, lanceolate, falcate; venation distinct, intramarginal vein removed from the edge, lateral veins very oblique, often approaching the venation of *E. coriacea*, A. Cunn. Peduncles axillary, not numerous, generally with about six to eight flowers. Calyx tube hemispherical, on a pedicel of about 2 to 3 lines; operculum hemispherical, acuminate, about the size of the calyx.

**Fruit.**—Pedicellate, hemispherical, rarely pyriform, occasionally ribbed; the rim broad or slightly countersunk; valves rarely or scarcely exerted; about 3 lines in diameter.



*In the mature stage they have the truncate edge of E. resinifera, but the valves are very small compared with that species.*

*The fruits in the early stages are somewhat similar in shape to those of E. stricta, Sieb., E. obtusiflora, and E. fraxinoides, but, perhaps, slightly smaller.*

**Habitat.**—Lawson, Mount Victoria, and road to Jenolan Caves, New South Wales. It was a tree of this species that Lawson, Blaxland, and Wentworth marked on their first attempt to cross the Blue Mountains, and which is now fenced in at Katoomba.

**REMARKS.**—This tree is allied to *E. Sieberiana*, F.v.M., in the venation, shape of the leaves, and timber, but it differs from it in its smooth bark, shape of fruits, paler timber, &c. When seen in its native habitat it might at first be passed as *E. saligna*, Sm., but differs from that species in the timber, fruit, and chemical constituent of its oil, and venation of the leaves. It is altogether distinct from *E. virgata*, Sieb., or *E. Luehmanniana*. This tree is mostly to be found at the head of gullies on the Blue Mountains, at the foot of precipitous sandstone cliffs, and near the foot of waterfalls, or on the edge of the pools. It also occurs on the ridges, as at Katoomba. It grows very tall, with scarcely a branch till near the top or head. The tree thought to be this species in Tasmania is *E. Risdoni*, Hook. f., the mature fruits of the two being somewhat alike.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Lawson, N.S.W., in May, 1899. The yield of oil was 1.2 per cent. The crude oil was almost colourless, and had a peppermint odour, due to the presence of a small amount of piperitone. It contained much phellandrene, but only a small amount of pinene. Cineol was present only in traces in the crude oil. Crystallised eudesmol was detected at the time of distillation. The third fraction consisted largely of the sesquiterpene.

The crude oil had specific gravity at 15° C. = 0.8869; rotation  $\alpha_D$  — 22.7°; refractive index at 20° = 1.4888, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 8.2.

On rectification, 2 per cent. distilled below  $174^{\circ}$  C. (corr.). Between  $174-193^{\circ}$ , 80 per cent. distilled; between  $193-245^{\circ}$ , 4 per cent. came over, and between  $245-280^{\circ}$ , 9 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8646; rotation  $a_D$  —  $30.8^{\circ}$ .

Second „ „ „ „ = 0.9147; „ „ not taken.

Third „ „ „ „ = 0.9377; „ „ not taken.

The above sample was stored in the dark, and in November, 1919, was again analysed. Very little alteration had taken place during the twenty years the oil had been kept, except that the optical rotation was reduced about 7 degrees. This alteration is apparently due to the phellandrene, as the loss in the rectified portion was about 5 degrees. 53 per cent. distilled below  $190^{\circ}$  C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ}$  C. = 0.9012; rotation  $a_D$  —  $15.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4884.

Rectified portion „ „ = 0.8636; rotation  $a_D$  —  $25.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4806.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil the result was 2 per cent.

## 160. *Eucalyptus Delegatensis*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1900, p. 305, t. XVI.)

Silver-topped Mountain Ash.

**Systematic.**—A very tall tree, occurring on the top of mountain ranges in the south-east corner of New South Wales, also Victoria, and Tasmania. Bark stringy, reddish, extending well up the trunk. Abnormal leaves large, broadly lanceolate, oblique; venation prominent, spreading, intramarginal vein removed from the edge. Normal leaves comparatively large, often 9 inches long and 2 inches broad, lanceolate, acuminate; venation prominent, lateral veins spreading, intramarginal vein removed from the edge. Peduncles axillary, about 6 lines long, slightly compressed, bearing from six to ten flowers. Buds clavate, 6 to 7 lines long; calyx tube short, merging into a pedicel 3 to 4 lines long; operculum hemispherical, obtuse.

**Fruit.**—Pyriform; rim thick, truncate or counter-sunk; valves small, not exserted; about 4 lines long and 3 lines broad.

*The fruits are uncommonly like those of E. Sieberiana and E. obliqua.*



**Habitat.**—Delegate Mountain, lower sides of Snowy Mountains, New South Wales; Victoria; Tasmania.

**REMARKS.**—It is difficult, from herbarium specimens to differentiate this species from *E. Sieberiana*, F.v.M., and *E. obliqua*, L'Her. The leaves are also similar to those of *E. levopinea*, R.T.B., but in the fruits and in its economic products it is quite distinct from that species. The buds are very similar to those of *E. Sieberiana*, F.v.M., but the timber, bark, and oil show it not to be that species, and the same may be said of *E. obliqua*. Maiden (Vict. Nat., vol. XVIII, p. 124) places this species as *E. dives*, Schau., from which *Eucalyptus* we find it differs in abnormal leaves, mature leaves, bark, timber, and the presence of an aroma in its leaves which is entirely absent from the true *E. dives*; he later places it with *E. gigantea*, Hooker's name for *E. obliqua*. We have fully discussed the claims of this species to specific rank in our "Eucalypts of Tasmania, and their Essential Oils," Roy. Soc. Tas., 1912, and where we show it is not *E. gigantea*. It can always be determined in the herbarium by the perfume emanating from the leaves when the box in which the material is contained is opened.



**ESSENTIAL OIL.**—Material for distillation was collected in July, 1908, at Mt. Wellington, Tasmania, at an altitude of about 2,500 feet above sea-level. The principal constituent in the oil of this species was phellandrene, and both cineol and pinene were almost absent. The peppermint constituent, piperitone, was present in small amount. The results obtained with the oil of this species from Tasmania are in remarkable agreement with those of the oil of this species from Delegate Mountain, southern New South Wales, collected in February, 1899 (results of which were published in the first edition of this work), although the distance separating these localities is great. The difference in the time of the year when the material was collected naturally influences the physical characters somewhat, because the principal terpene common in the oil of *Eucalyptus* species is usually present in greatest amount during the early summer months.

The yield of oil from leaves and terminal branchlets was 1.88 per cent. The crude oil was of a lemon-yellow colour. It had specific gravity at 15° C. = 0.8664; rotation  $a_D$  — 48.4°; refractive index at 20° = 1.4846, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 3.1.

On rectification, the usual amount of acid water and volatile aldehydes came over below 172° C. (corr.), at which temperature the oil commenced to distil. Between 172–183° C., 65 per cent. distilled; between 183–234°, 12 per cent., and between 234–270°, 16 per cent. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8532; rotation  $a_D$  — 54.2°; refractive index at 20° = 1.4795.

Second „ „ „ = 0.8764; rotation  $a_D$  — 35.6°; refractive index at 20° = 1.4830.

Third „ „ „ = 0.9004; rotation not taken; refractive index at 20° = 1.4932.

The low specific gravity of the high-boiling constituents of the oil of this species is worthy of remark, and is quite unusual for a first distillation.

The following tabulated results with the two oils show how closely they agree:—

|                                                   | Oil of <i>E. Delegatensis</i> .<br>(Mt. Wellington, Tas.,<br>July, 1908.) | Oil of <i>E. Delegatensis</i> .<br>(Mt. Delegate, N.S.W.,<br>February, 1899.) |
|---------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Yield of oil ... ..                               | 1.88 per cent.                                                            | 1.76 per cent.                                                                |
| Colour of crude oil ... ..                        | Lemon-yellow                                                              | Lemon-yellow.                                                                 |
| Phellandrene ... ..                               | Abundant                                                                  | Abundant.                                                                     |
| Cineol ... ..                                     | Practically absent                                                        | Practically absent.                                                           |
| Piperitone ... ..                                 | Present in small amount.                                                  | Present in small amount.                                                      |
| Specific gravity; crude oil at 15° C. ... ..      | 0.8664                                                                    | 0.8602.                                                                       |
| Rotation $a_D$ ... ..                             | — 48.4°                                                                   | — 58.6°.                                                                      |
| Refractive index at 20°C. ... ..                  | 1.4846                                                                    | 1.4863.                                                                       |
| Saponification number ester and free acid ... ..  | 3.1                                                                       | 3.5.                                                                          |
| Insoluble ... ..                                  | In 10 vols. 80 per cent alcohol.                                          | In 10 vols. 80 per cent. alcohol.                                             |
| Specific gravity, first fraction at 15° C. ... .. | 0.8532                                                                    | 0.8513.                                                                       |
| „ second fraction ... ..                          | 0.8764                                                                    | 0.8712.                                                                       |
| „ third fraction ... ..                           | 0.9004                                                                    | 0.9017.                                                                       |



It is thus seen that the characteristic features of the one oil are also shown with the other, and as the botanical material was quite in agreement it is evident that this species is common to both Tasmania and Eastern Australia.

Material of the "Gum-topped Stringybark" for distillation, was collected at Strickland, Tasmania, in August, 1912. The oil was found to agree in all respects with those recorded above. It contained the same constituents, practically in the same amounts, and the physical characters of the oils agree most closely. The specific gravity at  $15^{\circ} = 0.8596$ ; rotation  $a_D - 47.4^{\circ}$ ; refractive index at  $20^{\circ} = 1.4812$ , and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number of esters and free acid was 3.2. The yield of oil was 1.3 per cent., which is somewhat less than is usual with this species; but the time of the year probably accounts for this.

Material of the "Gum-topped Stringybark," growing at Lake Sorell, Tasmania, was sent for distillation in August, 1912. The trees were those originally mentioned by Mr. Stephens as growing at this locality. These trees are undoubtedly *Eucalyptus Delegatensis*, and the oil agreed with those from the "Gum-topped Stringybark," growing at Strickland, and Mt. Wellington, in Tasmania, and from the New South Wales trees of this species. The same constituents were present and in practically the same proportions, while the physical characters agree most closely. The specific gravity of the crude oil at  $15^{\circ} \text{ C.} = 0.8676$ ; rotation  $a_D - 47.7^{\circ}$ ; refractive index at  $20^{\circ} = 1.4819$ , and was insoluble in 10 volumes 80 per cent. alcohol. The comparative constancy in the characters of the oil of this *Eucalyptus* species is thus conclusively shown.

The results obtained with the Tasmanian material were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

The sample from Delegate Mountain was stored in the dark, and in November, 1919, was again analysed. Very little alteration had taken place during the twenty years the oil had been kept, except that the specific gravity had increased somewhat, and the optical rotation diminished about 27 degrees. This diminution in rotation is not wholly due to the phellandrene, because the loss on the rectified portion was only 10 degrees. It is evident that the alteration of the piperitone is largely responsible for the less rotation. 64 per cent. distilled below  $190^{\circ} \text{ C.}$  The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at  $15^{\circ} \text{ C.} = 0.8972$ ; rotation  $a_D - 30.8^{\circ}$ ; refractive index at  $20^{\circ} = 1.4883$ .

Rectified portion      „       $= 0.8567$ ; rotation  $a_D - 54.3^{\circ}$ ; refractive index at  $20^{\circ} = 1.4777$ .

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 3 per cent. of that constituent.



*EUCALYPTUS DELEGATENSIS*, R.T.B.  
SOUTHERN MOUNTAIN ASH.

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## 161. *Eucalyptus regnans*.

(F.v.M., in Report Acclm. Soc., Vict., 20, 1870.)

Giant Gum-tree.

**Systematic.**—A tree at last stupendously tall; bark outside whitish and smooth except at the stem base; leaves of young seedlings opposite, sessile, cordate-roundish, whitish from waxy bloom; leaves of rather thin texture, from elongate to broad lanceolate, much unilaterally curved, shining on both sides. their secondary venules slightly spreading; oil-dots extremely numerous and pellucid; umbels mostly solitary.

**Fruit.**—"Quite small, generally semi-ovate its border depressed or nearly flat; valves enclosed."



*The fruits are rather smaller than E. Delegatensis, which they somewhat resemble in shape.*

**Habitat.**—Victoria; Tasmania.

**REMARKS.**—The description given here is taken verbatim from Mueller's "Dichotomous Key to Victorian Plants," and is so explicit that that botanist must have had a strong species in view at the time of founding *E. regnans*. Deane and Maiden (Proc. Linn. Soc., N.S.W., 1899, p. 460) synonymise their own species, *E. fastigata*, with it; but as it is impossible to reconcile the Baron's description with the specific characters of their tree, a Eucalypt well known to us, we retain the two as distinct species. The tree known as *E. regnans* in Tasmania has quite a smooth bark, while *E. fastigata* has a stringy bark. Maiden (Crit. Rev., vol. I, p. 184) still later adheres to his classification of *E. fastigata*.

**ESSENTIAL OIL.**—Material for distillation was collected on Mt Wellington, Tasmania, in July, 1908. One sample of leaves with terminal branchlets was collected at a height of about 2,000 feet above sea-level, and another at about 2,500 feet. This tree is known locally in Tasmania as "Swamp Gum." The oils from both consignments were alike, showing that a difference in altitude has little influence on the secreted oil. The composition of the oil was also in agreement with that of *E. regnans*, from material sent for distillation from Yarra Junction, Victoria, by Cumming, Smith, and Company. This agreement is shown by the appended results, and is particularly marked with those derived from the several fractions. The comparative absence of dextro-rotatory pinene in the oil of *E. regnans* shows it to be a species distinct from *E. fastigata*, irrespective of botanical differences.

The oil of *E. regnans* consists largely of the terpene phellandrene, and contains a fair quantity of the stearoptene eudesmol. This substance was obtained in larger amount than is usual, by increasing the pressure of steam after the oil had distilled off in the usual manner; on allowing the distillate to remain for some hours in open vessels, the eudesmol could be removed as a crystalline fat-like mass from the surface of the water, and purified in the ordinary way.

The presence of cineol was doubtful even in the portion distilling at about 176° C., so that this frequently occurring constituent in Eucalyptus oils was only present in traces in that of *E. regnans*. The ester appeared to be almost entirely geranyl-acetate, as it saponified readily in the cold with two hours' contact. The ketone piperitone was only present in small amount. A considerable portion of the oil consisted of high-boiling constituents, probably the sesquiterpene largely; and the high-boiling fraction soon became solid after separation, due to the presence of the eudesmol.

The crude oils were reddish in colour, due to the action of the phenols on the iron derived from the still; on removing the colour, the oil was of a light-primrose tint. The two samples of oil had the following characters:—

|                                                     | Altitude, 2,500 ft. | Altitude, 2,000 ft. |
|-----------------------------------------------------|---------------------|---------------------|
| Yield of oil... ..                                  | 0.83 per cent.      | 0.78 per cent.      |
| Rotation $a_D$ ... ..                               | —28.4               | —31.1°              |
| Specific gravity at 15° C. ... ..                   | 0.8802              | 0.8879              |
| Ref. index at 20° C. ... ..                         | 1.4882              | 1.4901              |
| Solubility in 80 per cent. alcohol ... ..           | In 5 vols.          | In 5 vols.          |
| Cineol ... ..                                       | Practically absent  | Practically absent  |
| Eudesmol ... ..                                     | In quantity         | In quantity         |
| Phellandrene ... ..                                 | In abundance        | In abundance        |
| Saponification number of ester and free acid ... .. | 13.2                | 15.4                |

One of these oils was then rectified, and the results are here tabulated with those obtained with the oil of this species from Yarra Junction, in Victoria. Both oils commenced to distil at 170° C. (corr.).

|                                                   | Tasmanian Oil.     | Victorian Oil.                   |
|---------------------------------------------------|--------------------|----------------------------------|
| 170–176° C. ....                                  | 12 per cent.       | 10 per cent.                     |
| 176–190° C. ....                                  | 48 per cent.       | 35 per cent.                     |
| 190–240° C. ....                                  | 10 per cent.       | 4 per cent.                      |
| 240–280° C. ....                                  | 23 per cent.       | 45 per cent.                     |
| Specific gravity at 15° C., first fraction ... .. | 0.8532             | 0.8531                           |
| second fraction ... ..                            | 0.8559             | 0.8586                           |
| third fraction ... ..                             | 0.8818             | 0.8845                           |
| fourth fraction before solidi-<br>fication.       | 0.9515             | Not taken, soon<br>became solid. |
| Rotation $a_D$ , first fraction ... ..            | —41.8°             | —49.7°                           |
| second fraction ... ..                            | —40.2              | —46.4                            |
| third fraction ... ..                             | Light did not pass | Light did not pass               |
| Ref. Index at 20° C., first fraction ... ..       | 1.4796             | 1.4756                           |
| second fraction ... ..                            | 1.4821             | 1.4796                           |
| third fraction ... ..                             | 1.4852             | 1.4845                           |

The higher lævo-rotation of the first fraction, above that of the second fraction, together with other indications that dextro-rotatory pinene was not present, and the absence of cineol show the oil of this species not to agree with that of *E. fastigata*. The saponification number of the Victorian oil was 12.4. The comparatively small yield of oil from the leaves and branchlets of *E. regnans* renders the species of little value as an oil-producing tree.

As there was a strong indication for alcoholic bodies in this oil, the Tasmanian samples were mixed and a portion acetylated in the usual way. The saponification number was then 73.2, while in the cold with two hours' contact it was 31.5. This result indicates that about 16 per cent. of free eudesmol and 5 per cent. free geraniol were present at that time.

The results of this investigation with the Tasmanian material were published by us in the Proc. Roy. Soc., Tasmania, October, 1912.



## 162. *Eucalyptus gomphocephala*.

(D.C., in Prod., iii, 220, 1828.)

Tuart.

**Systematic.**—A large tree, up to 150 feet in height, and 20 feet in girth, with a smooth or rough "Box-like" persistent bark. Abnormal leaves ovate, lanceolate, petiolate. Normal leaves ovate-lanceolate to lanceolate or sometimes narrow lanceolate, falcate, acuminate, mostly under 6 inches in length, shining; venation not distinct in the older leaves, intramarginal vein sometimes well removed but often quite close to the edge, lateral veins fine, at about  $45^\circ$  to the mid-rib. Peduncles axillary or lateral, thick, broad and flat, 6 to 9 lines long, bearing two to six flowers. Buds sessile or shortly pedicellate; calyx tube obovoid 4 to 5 lines long; operculum hemispherical to conoidal, usually bluntly pointed much broader than the tube.

**Fruit.**—Sessile, bell-shaped or cylindrical, sometimes slightly flanged; rim broad, slightly counter-sunk to convex; valves exerted; 7 to 8 lines in length and 6 lines broad

*Mueller's figure stands quite alone in shape in his "Eucalyptographia." The fruit figured here is the most common form. It resembles somewhat E. obusta or E. patentinervis without a pedicel.*



**Habitat.**—Coastal limestone belts between Perth and Busselton, Western Australia.

**ESSENTIAL OIL.**—Material of this species was forwarded from Western Australia for distillation in May, 1904. It was obtained from trees growing in the sandy flat country around Perth. The yield of oil was small, less than two ounces of oil being obtained from over 400 pounds of material, collected as would be done for commercial distillation, so that the yield did not exceed 0.03 per cent. Such a small amount of oil did not permit of a complete investigation; it is evident however, that this species of *Eucalyptus* has no value as an oil-producing tree, as the constituents are of no special value.

The crude oil was reddish in colour, was quite mobile, and had a rank unpleasant odour. It was largely a terpene oil, as is suggested from the low specific gravity and insolubility in alcohol. An acetic acid ester was present, and this was almost entirely saponified in the cold with two hours' contact. The alcohol was probably geraniol, as the oil after saponification had an aromatic odour suggesting that substance. Cineol could not be detected. Phellandrene was present, as was also pinene, and probably terpinene also. The phellandrene nitrosite was prepared and this melted at  $112^\circ\text{C}$ .

The crude oil had specific gravity at  $15^\circ\text{C}$ . = 0.8759; rotation  $a_D$  —  $10.2^\circ$ ; refractive index at  $20^\circ$  = 1.4758, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 25.7.

It would be interesting to determine whether the abnormal leaves contain a more abundant supply of oil than the mature leaves, as it is not an infrequent occurrence with some *Eucalyptus* species for the secretion of the oil to practically cease in the old leaves. This is the only species we have received from Western Australia the oil of which contained phellandrene.



## 163. *Eucalyptus tæniola*.

(R.T.B. & H.G.S., Roy. Soc. Tas., p. 198, 1912.)

**Systematic.**—A tree of about 40 to 50 feet high and 2 feet in diameter, with a "peppermint" bark. Abnormal leaves opposite or alternate linear, lanceolate straight, 4 to 6 inches long and  $\frac{1}{2}$  inch wide. Normal leaves narrow, linear to linear-lanceolate, thin, up to 12 inches long; venation not pronounced, intramarginal vein removed from the edge lateral veins very oblique. Peduncles axillary, but sometimes apparently paniculate, angular, bearing few flowers. Calyx tube pyriform; operculum small, compressed, slightly pointed.

**Fruit.**—Pear-shaped, tapering to a short pedicel; rim countersunk; valves not exerted; up to 6 lines long and 3 lines wide.

*Morphologically they could easily be mistaken for E. virgata, Sieb., of this work.*



**Habitat.**—St. Mary's Pass, Tasmania.

**REMARKS.**—A species endemic to Tasmania and of restricted distribution in that Island.

**ESSENTIAL OIL.**—Material of this tree was collected for distillation at St. Mary's, Tasmania, in June, 1912. The yield of oil was 0.66 per cent. The crude oil was little-coloured, had a terpene odour, and contained much phellandrene; scarcely any pinene occurs, and only a very small amount of cineol. Eudesmol was detected. The oil belongs to the "Peppermint" group of Eucalypts, as it contained a small amount of piperitone. A considerable quantity of high-boiling constituents was also present, which consisted largely of the sesquiterpene. The yield of oil was too small for it to have commercial value.

The specific gravity of the crude oil at 15° C. = 0.8864; rotation  $a_D$  —27.6°; refractive index at 20° = 1.4844, and was soluble in 5 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was only 3.2.

On rectification, a few drops of acid water, and a little volatile aldehydes of a not unpleasant odour, came over below 173° C. (corr.). Between 173–198°, 68 per cent. distilled; between 198–265°, only 1 c.c. came over, and between 265–282°, 26 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8592; rotation  $a_D$  —45.1°; refractive index at 20° = 1.4794.

Second " " " " = 0.9408; dextro-rotatory 8 to 10°, but light did not pass well; refractive index at 20° = 1.5015.

The dextro-rotation of the higher-boiling fraction is due to the presence of eudesmol.

The cineol was determined by the resorcinol method in the portion distilling below 198°; when calculated for the crude oil the result was 7 per cent.

These results indicate that this Eucalypt is somewhat closely associated with the Tasmanian *E. virgata*. The oil from the latter, however, contained more cineol and more eudesmol, while that of *E. tæniola* had more phellandrene, as indicated by the rotation figures.

The analysis of the oil of this species was published by us in the Proc. Roy. Soc., Tasmania, October, 1912.

## 164. *Eucalyptus Andrewsii*.

(J.H.M., Proc. Linn. Soc., N.S.W., 1904, p. 472.)

**New England Peppermint.**

**Systematic.**—A tall tree averaging 80 feet in height, reaching in some situations 150 to 180 feet (J.H.M.); bark "Peppermint" like. Abnormal leaves ovate, alternate, glaucous, about 5 inches long and 2 inches broad. Normal leaves lanceolate to broad-lanceolate, falcate, acuminate, usually under 6 inches long; intramarginal vein removed from the edge, lateral veins very oblique. Flowers in umbels or sometimes in panicles, peduncles axillary or lateral. Buds clavate, pedicellate; operculum somewhat shorter than the calyx tube, shortly pointed.

**Fruit.**—Hemispherical to turbinate, pedicellate; rim broad, slightly domed; valves scarcely exerted; 3 lines long and 3 lines in diameter.



*The nearest in resemblance to these fruits amongst its congeners are those of E. dives.*

**Habitat.**—New England, New South Wales; Southern Queensland.

**REMARKS.**—This is one of the many Eucalypts going under the common name of "Peppermints" in New England, where it is also known as "Blackbutt" and "Messmate." The former, however, is the more appropriate.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Tenterfield in January, 1910. The material was collected as would be done for commercial distillation. The yield of oil was 1.27 per cent. The crude oil was of a lemon-yellow tint, and had a secondary odour of peppermint. It had all the appearances and characters of a "Peppermint" Eucalyptus oil, and resembled very closely those distilled from the group of which *E. dives* may perhaps be considered the type. The principal constituents in the oil were lævo-rotatory phellandrene, piperitone, and the sesquiterpene, of which the first predominated greatly, in fact this species may be considered as yielding one of the most pronounced phellandrene-bearing Eucalyptus oils of the whole group, not even excepting *E. radiata*. Pinene appears to be quite absent, and cineol was only detected with difficulty. The amount of ester was very small, and this might be expected for an oil of this nature.

The crude oil had specific gravity at 15° C. = 0.8646; rotation  $\alpha_D$  — 41.5°; refractive index at 20° = 1.4831, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.3.

After acetylation, the saponification number was 57.67, which calculated for free alcohol having a  $C_{10}H_{18}O$  molecule, gives 15.3 per cent. The ketone absorption was 5 per cent. The alcohol was probably piperitol largely.



On rectification only 1 per cent. of acid water and volatile aldehydes distilled below  $174^{\circ}$  C. (corr.). Between  $174$ – $178^{\circ}$ , 56 per cent. distilled; between  $178$ – $182^{\circ}$ , 26 per cent. distilled, and between  $182$ – $194^{\circ}$ , 6 per cent. distilled. The temperature then rose to  $245^{\circ}$ , and between  $245$ – $255^{\circ}$ , 8 per cent. distilled. These fractions gave the following results:—

|                |                                                                                                                   |
|----------------|-------------------------------------------------------------------------------------------------------------------|
| First fraction | sp. gr. at $15^{\circ}$ C. = 0.8508; rotation $a_D$ — $47.2^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4805. |
| Second         | „ „ „ = 0.8563; rotation $a_D$ — $44.0^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4825.                      |
| Third          | „ „ „ = 0.8749; rotation $a_D$ — $32.9^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4848.                      |
| Fourth         | „ „ „ = 0.9034; rotation not taken; refractive index at $20^{\circ}$ = 1.4954.                                    |

The nitrosite was prepared with the phellandrene, and it was possible to separate this into two forms, one melting at  $112$ – $113^{\circ}$ , the other at  $105^{\circ}$  C.

In view of the prominence recently acquired by the phellandrene Eucalyptus oils in the separation of metallic sulphides from ores by a flotation process, this species has commercial value as an oil-producing tree. The yield, however, is much lower than with some species—*E. dives* for instance. At the present time, no other species growing in the New England District of New South Wales is known from which a greater yield of a pronounced phellandrene oil can be obtained.

The results of this investigation were published by us in the Proc. Roy. Soc., N.S.W., Nov., 1911.

## 165. *Eucalyptus dives*.

(Schauer, in Walp. Rep., ii, 926.)

**Peppermint or Broad-leaved Peppermint.**

**Systematic.**—A tree often attaining very large dimensions, although it is found in flower and fruit when only a few feet high (Mittagong Ranges, Berrima Coal Mine, Fagan's Creek, Braidwood District), and when its leaves are sessile, cordate. Bark greyish, furrowed, and somewhat similar in appearance to that of the "Messmate" (*E. phellandra*), but yet of a stringy nature. Abnormal leaves ovate cordate sessile, measuring several inches in length; venat on marked, intramarginal vein removed from the edge. Normal leaves lanceolate, petiolate; venation well marked on both sides, very oblique, intramarginal vein removed from the edge. Flowers numerous, up to twenty, on axillary peduncles under 1 inch long.

**Fruit.**—Varying between pear-shaped and hemispherical, shining; rim thick; valves not exerted or only slightly so; 3 lines in diameter.



*These somewhat resemble E. amygdalina and allied species, and the smaller forms of E. vitrea.*

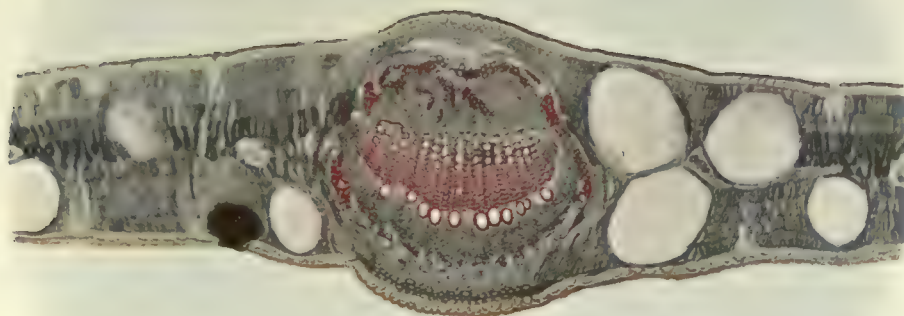
**Habitat.**—Common throughout the whole coastal ranges of New South Wales and Victoria.





EUCALYPTUS DIVES, SCH.  
A BROAD LEAF PEPPERMINT.

UNIVERSITY OF  
CALIFORNIA



This species which yields so large a quantity of oil, was naturally expected to have large and numerous oil glands as are shown in the plate. The palisade tissue is of less area on the upper than the lower side of the mesophyll, which, in this case stands out more distinctly than in most sections illustrated. The cuticle shows no variation on either side of the leaf. The mid-rib in the centre of the plate illustrates the typical bicollateral structure of the vascular system of the Eucalypts, the xylem being bordered top and bottom by phloem. Towards the upper side of the xylem are the elements of the protoxylem, lower down are the smaller xylem fibres, and lower again the larger vessels. Outside the phloem are the thick-walled strengthening fibres and further layers of supporting tissue. The black spot on the left of mid-rib is a fungus.

× 55.

Univ. of  
California

EUCALYPTUS DIVES, SCHAU.



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anagruao

**REMARKS.**—Both Bentham and Woolls were in accord with Schauer in regarding this tree as a distinct species, but Mueller synonymised it with *E. amygdalina*, Labill., and this has caused the latter species to lose much of its good name concerning its economics, as, for instance, its oil. In a natural classification the two species never can be confounded. The leaves of *E. dives* are very variable in shape and size, being either sessile, opposite and cordate or ovate-lanceolate on the same tree. It also flowers and fruits in a very early stage of its growth (5 to 6 feet), when the peduncles at the base of the cordate, sessile leaves, differentiate it from *E. amygdalina*, whilst in this latter feature it resembles the "Argyle Apple" (*E. cinerea*, F.v.M.) or *E. pulverulenta*. The early foliage is also quite different from that of *E. amygdalina*, not to mention the nature of the bark, timber, and constituents of the oil. It is, therefore, all the more difficult to understand how, on morphological grounds, the two should have been thought to be one and the same species. It is quite a distinct tree.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Fagan's Creek, Braidwood, N.S.W., in October, 1898. The yield of oil was 1.96 per cent. The crude oil was almost colourless, and had a strong peppermint odour, due to the large amount of piperitone it contained. It consisted very largely of phellandrene. Cineol did not exceed 5 to 8 per cent. in the crude oil. The third fraction consisted largely of the peppermint ketone, piperitone.

The crude oil had specific gravity at 15° C. = 0.882; rotation  $a_D$  — 63.9°; refractive index at 20° = 1.4837, and was soluble in 2 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.9.

On rectification, 2 per cent. distilled below 172° C. (corr.). Between 172–198°, 60 per cent. distilled; between 198–227°, 13 per cent. came over, and between 227–240°, 20 per cent. distilled. These fractions gave the following results:—

|                                                                                                 |
|-------------------------------------------------------------------------------------------------|
| First fraction, sp. gr. at 15° C. = 0.8593; rotation $a_D$ — 73.8°.                             |
| Second     "                 "                 "     = 0.8936;                 "     not taken. |
| Third       "                 "                 "     = 0.9318;                 " $a_D$ — 9.4°. |

Material of this species for distillation was also obtained from Barber's Creek, N.S.W., in October, 1898. The yield of oil was 2.1 per cent.; the crude oil differed in no respect from the above sample, and this result is a good illustration of the comparative constancy of constituents in the oil of the same species at the same time of the year. The specific gravity of the crude oil was 0.882, and optical rotation  $a_D$  — 63.6°. The crude oil formed a clear solution with 1 volume 80 per cent. alcohol, and the peppermint ketone, piperitone, was present in great quantity in this sample.

Material of this species for distillation was also obtained from Berrima, N.S.W., in May, 1899. The yield of oil was 2.9 per cent. The specific gravity of the crude oil was 0.8887, and optical rotation  $a_D$  — 55.8°. It was in agreement in all respects with those mentioned above, and formed a clear solution with 1 volume 80 per cent. alcohol.

Material of this species was also obtained from Rylstone, N.S.W., in August, 1898. The oil was practically identical with the above.

During recent years, considerable quantities of the oil of this species have been distilled in Australia. It is the best of all essential oils for use in the Mining Industry for the separation of mineral sulphides by a flotation process, and as the yield is large it can be produced somewhat cheaply. Previously the oil of *E. dives* was forwarded to Europe as the product of *E. amygdalina*; that this is so can be seen from the study of the constants recorded in the older literature.

The oil of *E. dives* shows a comparative constancy similar to those of other individual Eucalypts, so that the species has now become stabilised.

This subject is more fully treated in the article "The comparative constancy of the oil products from individual species of Eucalyptus."

The cineol in the oil of this species is always small in amount, averaging probably between 5 and 8 per cent. It is impossible to determine this small amount accurately by the phosphoric acid method, or by any other known method besides absorption with 50 per cent. resorcinol. Statements have been made that the resorcinol method indicates the presence of a much larger quantity of cineol than the oil actually contains, and that is so, if the results of the direct absorption be taken without correction. On rectifying the oil so as to separate the constituents boiling between 170–190° C., a considerable quantity of piperitone comes over, and is absorbed by the resorcinol at the same time as the cineol. The piperitone can, however, be readily estimated by a ketone determination, using the normal sodium sulphite method, and the amount so found when subtracted from the total absorbed, will give the cineol.

An actual determination will make this clear. A sample of freshly-distilled oil of *E. dives* was forwarded to us by Mr. A. J. Bedwell, in November, 1919; it was typical of the oil of this species. The crude oil had:—

|                                               |            |     |     |     |                  |
|-----------------------------------------------|------------|-----|-----|-----|------------------|
| Specific gravity at 15° C.                    | ...        | ... | ... | ... | = 0.8828.        |
| Optical rotation $a_D$                        | ...        | ... | ... | ... | — 68.0°          |
| Refractive index at 20°                       | ...        | ... | ... | ... | = 1.4769.        |
| Soluble in 1 volume 80 per cent. alcohol.     |            |     |     |     |                  |
| Ketone determination                          | ...        | ... | ... | ... | = 29 per cent.   |
| 65 per cent. distilled below 190° C. (corr.). | This had:— |     |     |     |                  |
| Specific gravity at 15°                       | ...        | ... | ... | ... | = 0.8592.        |
| Rotation $a_D$                                | ...        | ... | ... | ... | — 77.2°.         |
| Refractive index at 20°                       | ...        | ... | ... | ... | = 1.4734.        |
| Resorcinol absorption                         | ...        | ... | ... | ... | = 22.5 per cent. |
| Ketone determination                          | ...        | ... | ... | ... | = 10.0 per cent. |
| Cineol after correction                       | ...        | ... | ... | ... | = 12.5 per cent. |

When calculated for the original oil the result was 8 per cent. of cineol.

The portion boiling above 190° C. (35 per cent. of original oil), had specific gravity at 15° C. = 0.9335; rotation  $a_D$  — 38.2°; refractive index at 20° C. = 1.4855; and ketone estimation 75 per cent.

The non-ketone portion of the original oil had specific gravity at 15° C. = 0.8633; rotation  $a_D$  — 70.2°; refractive index at 20° = 1.4746; saponification number = 15.93, and after acetylation = 38.35, which calculated for a  $C_{10}H_{18}O$  alcohol gives 6.3 per cent. This alcohol is probably piperitol, largely, as in the oil of *E. radiata*.

## 166. *Eucalyptus radiata*.

(Sieb., in DC. Prod., iii, 218.)

White-top Peppermint or River White Gum.

**Systematic.**—A fairly tall tree. It has a hard, black bark on the lower part of the trunk, but smooth on the upper portion of the tree. Abnormal leaves thin, sessile, or almost perfoliate, much resembling those of the “Messmate” *E. phellandra*, opposite, narrow, about 3 to 4 inches long, marginal vein slightly removed from the edges. Normal leaves lanceolate, narrow, generally about



6 inches long, membranous, on a petiole of about 1 inch long; venation not prominent, intramarginal vein removed from the edge, lateral veins oblique, spreading. Flowers very numerous, up to thirty, on axillary peduncles. Calyx tube turbinate, or truncate spherical, small, 1 line long, tapering to a long filiform pedicel; operculum obtuse.

**Fruit.**—Numerous, small, pilular, on filiform pedicels; rim thin, contracted; valves not exerted; 2, rarely 3, lines in diameter.

*A fruit with little variation in shape and often more globular than depicted here.*



**Habitat.**—On river banks and mountain ranges of the coast district, but preferring banks of creeks, New South Wales.

**REMARKS.**—This Eucalyptus has had a "battledore-and-shuttlecock" experience at the hands of systematists since its naming by Sieber in "De Candolle's Prodromus," iii, 218, 1828. Benthams, B.Fl., iii, p. 203, gives its varietal rank under *E. amygdalina*, Labill., and Mueller, in "Eucalyptographia," synonymises it altogether under that species. This action Dr. Woolls strongly opposed, for he states ("Flora of Australia," p. 239): "No one who has had an opportunity of examining both trees in a living state would suppose them to be allied, as they vary so much from each other in bark and habit," and to this we would add morphological and physical properties. Next Deane and Maiden also place it as a variety of *E. amygdalina*, Proc. Linn. Soc., N.S.W., Vol. 20, p. 603. Maiden later, however, synonymises it under *E. amygdalina*, "A Critical Rev.," Vol. I, p. 151, but restores it to specific rank (Proc. Roy. Soc. N.S.W., Vol. 51, p. 461), placing our *E. Australiana* as a synonym. Dr. Woolls was familiar with the tree in the field under the common name of "River White Gum," and Benthams reproduces this name for it under Woolls' authority. Sieber travelled where the "River White Gum" now occurs, and the attempt made to place *E. Australiana* as Sieber's tree is difficult to understand, as there is nothing to show that that author ever travelled into what was in 1834 remote and inaccessible parts of the Colony, and so the chances are all in favour that he never saw this latter tree, as it is only within the last few years that the district has been opened up; and, besides, Sieber's description does not match *E. Australiana*, but it does match what has been known and is still recognised as the "River White Gum" of Woolls. Sieber's *E. radiata* is acknowledged in our first edition, and no new data appear to us to have been brought to light to warrant our placing *E. Australiana*, which has a Peppermint bark, as a synonym of this smooth bark tree—now Maiden's *E. numerosa*. (Proc. Roy. Soc., N.S.W., Vol. LI). Sieber's *E. radiata* we regard as the "River White Gum."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Monga, N.S.W., in September, 1898. The yield of oil was 1.88 per cent. The crude oil was almost colourless, and had a peppermint odour due to the presence of piperitone. It contained much phellandrene, but pinene was only detected in small amount. Only a very small quantity of cineol was found in the portion distilling at near the boiling point of that constituent.

A close agreement is noticeable between the oil of this species and that of *E. dives*, the only apparent differences being that the pinene was more pronounced in the oil of *E. radiata* than in that of *E. dives*, and contained less piperitone, consequently the oil commenced to distil at a lower temperature. Esters were not pronounced, and crystallised eudesmol was not detected.

The crude oil had specific gravity at 15° C. = 0.8747; rotation  $a_D$  — 65.1°; refractive index at 20° = 1.4806, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 4.4.

On rectification, 2 per cent. distilled below 162° C. (corr.). Between 162–183°, 58 per cent. distilled; between 183–204°, 22 per cent. came over, and between 204–235°, 13 per cent. distilled. These fractions gave the following results:—

|                 |                   |           |                |                            |
|-----------------|-------------------|-----------|----------------|----------------------------|
| First fraction, | sp. gr. at 15° C. | = 0.8546; | rotation $a_D$ | — 71.4°.                   |
| Second          | "                 | "         | "              | = 0.8677; " $a_D$ — 56.5°. |
| Third           | "                 | "         | "              | = 0.9200; " $a_D$ — 1.7°.  |

Material of this species for distillation was also obtained from Wingello, N.S.W., in September, 1900. The yield of oil was 1.2 per cent. The oil was practically identical with that previously obtained from Monga, except that rather more phellandrene was present, and consequently the rotation to the left was somewhat higher. The following results show this clearly.

The crude oil had specific gravity at 15° C. = 0.8695; and rotation  $a_D$  — 77.7°; 57 per cent. distilled between 166–183°; 15 per cent. between 183–224°, and 13 per cent. between 224–240°.

First fraction, sp. gr. at 15° C. = 0.8512; rotation  $a_D$  — 83.8°.

Second „ „ „ = 0.8681; „ not taken.

Third „ „ „ = 0.9290; „ „

The saponification number for the esters and free acid was 2.8.

Material for distillation was obtained from Hill Top, N.S.W., in November, 1919. The yield of oil was 2.9 per cent. The crude oil was but little coloured, had a peppermint odour, and consisted principally of phellandrene, together with small quantities of piperitone and piperitol.

The crude oil had specific gravity at 15° C. = 0.8643; rotation  $a_D$  — 59.75°; refractive index at 20° = 1.4777, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 8.4, and after acetylation 35.8.

On rectification, 73 per cent. distilled below 180° C.; between 180–200°, 18 per cent. came over, and between 200–265°, 6 per cent. distilled. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8526; rotation  $a_D$  — 66.5°; refractive index at 20° = 1.4763.

Second „ „ „ = 0.8659; rotation  $a_D$  — 55.4°; refractive index at 20° = 1.4792.

Third „ „ „ = 0.8987; rotation  $a_D$  — 28.0°; refractive index at 20° = 1.4865.

Absorption by normal sodium sulphite showed that 5 per cent. of the crude oil consisted of piperitone.

For the investigation of the alcohol piperitol, see the article on that substance in this work.

## GROUP VIII.

In this Group are placed the following EUCALYPTS yielding an oil not readily placed in the other groups. Cineol is almost or quite absent.

- |      |                   |                       |
|------|-------------------|-----------------------|
| 167. | <i>Eucalyptus</i> | <i>virgata.</i>       |
| 168. | <i>E.</i>         | <i>stellulata.</i>    |
| 169. | <i>E.</i>         | <i>Macarthuri.</i>    |
| 170. | <i>E.</i>         | <i>aggregata.</i>     |
| 171. | <i>E.</i>         | <i>Staigeriana.</i>   |
| 172. | <i>E.</i>         | <i>patentinervis.</i> |
| 173. | <i>E.</i>         | <i>citriodora.</i>    |
| 174. | <i>E.</i>         | <i>Marsdeni.</i>      |
| 175. | <i>E.</i>         | <i>ligustrina.</i>    |
| 176. | <i>E.</i>         | <i>apiculata.</i>     |
-



## 167. *Eucalyptus virgata*.

(Sieb., in DC. Prod., iii, 217.)

**Systematic.**—An average forest tree, stated by Rodway to attain a height of over 100 feet; branchlets glaucous; bark thick, laminated, running down in ridges, friable, inner portion hard, close, compact, in cross-section, the duramen difficult to determine from the normal wood. Abnormal leaves mostly alternate, petiolate, sometimes glaucous, thin, oval-lanceolate to lanceolate, acuminate, 4 to 5 inches long, up to  $1\frac{1}{2}$  inch broad; venation distinctly marked, lateral veins not very oblique, intramarginal vein removed from the edge. Normal leaves comparatively small, rarely 5 inches long, mostly from 2 to 4 inches long, up to  $\frac{1}{2}$  inch broad, lanceolate, shining, sub-coriaceous; venation inconspicuous, lateral veins well oblique, a few running almost longitudinally parallel from the petiole; intramarginal vein removed from the edge. Flowers on axillary peduncles or in short panicles; operculum hemispherical, shortly acuminate.

**Fruit.**—Pyriform, contracted at the top; rim countersunk; valves inserted; up to 6 lines long, 3 lines in diameter.



*The differences between E. virgata, Sieb., and E. Sieberiana are found principally in the smaller leaves, countersunk rim of the smaller fruits, timber, and chemical constituents of the oil of the former. They are rather difficult to separate in herbarium material alone.*

**Habitat.**—Springwood, Lawson, Mount Victoria; Blue Mountains, New South Wales; Tasmania.

**REMARKS.**—From Sieber's specific name there can be little doubt but that he intended his description to apply to a small twiggy *Eucalyptus*, with exactly the same morphological features (as later researches have shown) as the present "Mountain Ash," *E. Sieberiana*, F.v.M., and these characteristics of the two species are proved by Bentham's note, B.Fl. iii, p. 202, for under *E. virgata* he states: "I have described this species chiefly from Oldfield's, Woolls', and F. Mueller's specimens; Sieber's appear to be the same, but they are only in the young bud, and therefore uncertain." There is, on the Blue Mountains, a dwarf *Eucalyptus*, or "Mallee," the herbarium material of which cannot be separated from that of the tall tree, *E. Sieberiana*, but the chemical constituents of each are quite different. It is very probable that Oldfield's, Woolls', and Mueller's specimens belong to the tall tree, known as "Mountain Ash," and since named by Mueller as *E. Sieberiana*, whilst Sieber's specimens no doubt belong to the dwarf tree or "Mallee," and, as Bentham found, quite impossible of separation in dried material. If this is correct, then Sieber's tree only differs in field and chemical characters, and on these we accept Sieber's name for the mountain shrub which has identical morphological characters with *E. Sieberiana*, F.v.M.

Our action in regard to this species will, no doubt, be thought to be arbitrary, but we, on our part, think that Oldfield, Woolls, Mueller and others when dealing with type herbarium specimens were in error in supposing that Sieber's specimens and specific name belonged to the "Mountain Ash," *E. Sieberiana*. Sieber must have collected from a "Mallee" when he bestowed the name *E. virgata* on his species, and as his specimens almost exactly match those of this larger tree, it would, therefore, be quite easy for Bentham and Mueller also working on these dried materials, to confound these *Eucalypts*. We were in error ourselves until convinced by the chemical investigation of *E. virgata*. The results proved conclusively that his views based upon field observations, were quite correct, and we think that the identity of *E. virgata* of Sieber is now clearly shown. Material of *E. Luehmanniana*, F.v.M., could never have been confounded with this species, as they are so dissimilar.

In our work on Tasmanian *Eucalypts*, Roy. Soc. Tas., 1912, we record this species from that Island, where it grows to an average tree size.

The history of this species at the hands of systematists is interesting:—It was described as a species by Sieber, DC., Prod. iii, 217. Bentham in his "Flora Australiensis," vol. iii, 202, gives it specific rank. Mueller, in "Eucalyptographia," Dec. 2, 1880, places it under *E. Sieberiana*, and later, Dec. 10, 1884, synonymises it under *E. stricta*; later in his second Census, 1889, he restores the name. Deane and Maiden, in Proc. Linn. Soc., N.S.W., 1897, p. 717, discuss its affinities at great length, and state that it oscillates between *E. Luehmanniana* and *E. obtusiflora*, and finally that "all that remains is to give the name of *E. virgata* decent interment. . . ." Maiden, in his "Critical Revision of the Genus Eucalyptus," Vol. 1, p. 273, 1907, states that *E. virgata* and *E. stricta* are conspecific. Later in the same work, Vol. 4, p. 284, 1919, Maiden raises the tree to specific rank and places it above *E. Luehmanniana*, F.v.M., stating, however, that it (*E. virgata*) is confined to New South Wales.

**ESSENTIAL OIL.**—Material for distillation was obtained from Springwood, N.S.W., in September, 1899. The yield of oil was 0.29 per cent. When distilled the oil was found to consist very largely of crystallised eudesmol, that substance being present in such quantity that the oil solidified in the receiver. A fresh consignment of leaves was then received, and this on distillation gave similar results. The material thus obtained was undoubtedly the most remarkable Eucalyptus oil we had seen up to that time. Only traces of cineol were detected, while the low-boiling terpenes consisted principally of phellandrene. The oil of this species has little resemblance to that obtained from *E. Sieberiana*, as eudesmol does not occur in the oil of the latter species. The peppermint constituent, piperitone, is present in small amount in the oil of *E. virgata*. Fresh material of *E. Sieberiana* was obtained on purpose to test the constancy, but the oil corresponded with that obtainable at all times from the leaves of *E. Sieberiana*, and had little resemblance to that derived from this species, owing to the absence of eudesmol. The oil distilled from the first consignment of leaves was analysed with the following results:—

The crude oil had specific gravity at 15° C. = 0.9154; refractive index at 20° = 1.4958, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 5.7.

On rectification, 1 per cent. distilled below 173° C. (corr.). Between 173–188°, 54 per cent. distilled; between 188–272°, 10 per cent. came over, and between 272–285°, 31 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8683; rotation  $a_D$  — 31.08°.

Second    ,,        ,,        ,,        = 0.8796;        ,,        — 17.40°.

Several years later, in June, 1912, material for distillation was obtained from St. Mary's, Tasmania. The yield of oil was 0.79 per cent., which is greater than that from the N.S.W. trees. The oil consisted largely of phellandrene and eudesmol, the terpene in the greater proportion, and the eudesmol in correspondingly less amount than was present in the Australian oil, otherwise the agreement was very close; this can be seen from the following results. The crude oil was but little coloured, and had a secondary odour of peppermint, due to the presence of a small quantity of piperitone. Cineol was readily detected in small amount.

The principal constituent in this oil was phellandrene, and pinene probably absent. Eudesmol was present in quantity, the high-boiling fraction becoming solid after a few hours. Only a very small amount of ester was present in the crude oil. Although the phellandrene shows the lævo-rotatory modification in excess, yet, judging from the comparatively small rotation, and the almost entire absence of pinene, it seems possible that the phellandrene of opposite rotation was also present. So far dextro-rotatory phellandrene has not been isolated from any Eucalyptus oil.

The crude oil had specific gravity at 15° C. = 0.8883; rotation  $a_D$  — 20.9°; refractive index at 20° = 1.4810, and was soluble in 3 volumes 80 per cent. alcohol. This comparatively ready solubility is largely due to the presence of eudesmol. The saponification number for the esters and free acid was 3.3.



On rectification, the usual amount of acid water and volatile aldehydes came over below  $173^{\circ}$  C. (corr.); the aldehydes however, were much less pungent and objectionable than are those from the oils of the pinene-cineol groups. Between  $173$ – $198^{\circ}$ , 78 per cent. distilled; the temperature then rose quickly to  $265^{\circ}$ , only 1 c.c. distilling; between  $265$ – $282^{\circ}$ , 17 per cent. distilled. These fractions gave the following results :—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8713; rotation  $a_D$  —  $29.5^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4796.

Second „ „ „ = 0.9421; rotation not taken; refractive index at  $20^{\circ}$  = 1.5062.

The cineol was determined in the first fraction by the resorcinol method; when calculated for the crude oil the result was 21 per cent. Other substances than cineol were evidently absorbed, as only about 10 to 12 per cent. was indicated by other methods. The large amount of eudesmol caused the high-boiling fraction to soon become solid, and this peculiarity is quite a distinguishing feature between the oil of this species and that of *E. Sieberiana*.

## 168. *Eucalyptus stellulata*.

(Sieb., in DC. Prod., iii, 217.)

Lead Gum, Black Sally.

**Systematic.**—Generally a moderate-sized tree, but on the Monaro, N.S.W., attains a diameter of 4 to 5 feet; bark smooth, lead-coloured, but passing through various shades into green; sometimes persistent some distance up the stem of large trees, when it is rough and thick, almost like that of an "Ironbark." Abnormal foliage glaucous, leaves ovate, shortly acuminate, tapering at the base, thin, 3 to 4 inches long, six- or seven-nerved. Normal leaves mostly ovate, up to 4 inches long, broad to lanceolate; venation marked and characteristic, generally three or more veins radiating from the base and extending almost the whole length of the leaf, and thus indicating phellandrene in the oil. Peduncles axillary, short, with numerous sessile flowers, in stellate clusters. Calyx small, about 1 to 2 lines long; operculum conical, acute.

**Fruit.**—Pilular, small, sessile in axillary clusters; rim contracted, shining or glabrous; valves not exerted; 2 lines in diameter.



*The fruits are difficult to separate from those of E. Moorei.*

**Habitat.**—New England Tableland, N.S.W., and into Victoria.

**REMARKS.**—This is a very marked species, and easily distinguished in the field and herbarium from its congeners by its stellate cluster of buds, its small, almost spherical fruit, and its longitudinal lateral veins, similar to those of *E. coriacea*, A. Cunn., and *E. vitrea*, R.T.B. The timber is pale coloured, hard, durable, and seasons well. It occurs on some of the highest and most exposed positions of the Coast Range. The number of common names applied to it is large, but the two given above are the most common.



**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Rylstone, N.S.W., in August, 1898. The yield of oil was 0.3 per cent. The crude oil was of an amber colour, and had an odour corresponding to that of the phellandrene Eucalyptus oils. Phellandrene was present in considerable quantity, but pinene only in small amount. Cineol was only found in small amount in the first fraction. The peppermint ketone, piperitone, was not pronounced, but a constituent having a cinnamon-like odour was present in the second fraction. The third fraction consisted largely of the sesquiterpene. Crystallised eudesmol was not detected.

The crude oil had specific gravity at 15° C. = 0.871; rotation  $a_D$  — 22.7°; refractive index at 20° = 1.4845, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.1.

On rectification, 1 per cent. distilled below 173° C. (corr.). Between 173–183°, 80 per cent. distilled; between 183–245°, 11 per cent. came over, and between 245–266°, 4 per cent. distilled. These fractions gave the following results:—

|                                   |          |                |            |
|-----------------------------------|----------|----------------|------------|
| First fraction, sp. gr. at 15° C. | = 0.863; | rotation $a_D$ | — 24.6°.   |
| Second „ „ „                      | = 0.880; | „              | — 19.7°.   |
| Third „ „ „                       | = 0.931; | „              | not taken. |

The above sample was stored in the dark, and in November, 1919, was again analysed. Very little alteration had taken place during the twenty-one years the oil had been kept, although the phellandrene had suffered some loss in rotation. 83 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

|                              |           |                |          |                         |           |
|------------------------------|-----------|----------------|----------|-------------------------|-----------|
| Crude oil, sp. gr. at 15° C. | = 0.8782; | rotation $a_D$ | — 17.4°; | refractive index at 20° | = 1.4844. |
| Rectified portion „          | = 0.8644; | rotation $a_D$ | — 21.5°; | refractive index at 20° | = 1.4801. |

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was 8 per cent.

## 169. *Eucalyptus Macarthuri*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 448, t. XXXVIII.)

**Paddy's River Box, Camden Woollybutt.**

**Systematic.**—A medium-sized tree, with a rough, somewhat “Box”-like bark. Abnormal leaves linear-lanceolate, slightly cordate, barely stem clasping, sessile, and opposite, bright green in colour, of similar tint on both sides. Normal leaves alternate, narrow lanceolate, often falcate, thickish, of equal colour on both sides; venation not prominent, intramarginal vein at some distance from the edge. Umbels axillary, with short, scarcely flattened peduncles,

and pedicels absent, or nearly so. Buds small, the operculum and calyx of approximately equal size, the former but very slightly conical, up to eight in the head, but perhaps five on the average.

**Fruit.**—Hemispherical, slightly dilated at the rim, which is well defined; valves usually three, but rarely four, scarcely exserted, 2 to 3 lines in diameter.



*These so much resemble those of E. Rodwayi that some systematists have confounded the two. They are also very close in shape to E. aggregata and E. acaciæformis.*

**Habitat.**—Confined to the counties of Camden and Argyle, New South Wales, as far as known at present. Prefers swampy or low-lying land, or the banks of streams; Mittagong, Bowral, and Moss Vale, New South Wales.

**REMARKS.**—Bentham thought this species had an affinity with *E. viminalis*, but, except in the abnormal and mature leaves, the affinity does not appear to be marked. Its narrow abnormal leaves and small fruits should prevent its confusion with *E. Bridgesiana*, R.T.B. It is a very distinct species in the field, and could not be confused with other Eucalypts. The odour of the leaves when crushed at once distinguishes this species from all others with the exception of that of *E. acervula*. The remarks of the authors of the species (*loc. cit.*) on *E. diversifolia* apply to their *E. rubida*, and not to this species.

**ESSENTIAL OIL.**—In the year 1900, the discovery was made that the oil of *Eucalyptus Macarthuri* was of quite an exceptional character, in that it consisted very largely of geranyl-acetate and free geraniol. (See paper by one of us, Proc. Roy. Soc., N.S.W., Nov., 1900.) Since that time a considerable amount of work has been done upon the oil of this species, and it has always been found to be in agreement with the results originally published. The species has become of importance for the production of an oil for perfumery purposes, and is now being cultivated in Victoria. The species grows to a large size and has a thick aromatic bark, which also produces an essential oil similar in composition with that from the leaves. (See Proc. Roy. Soc., N.S.W., October, 1916.) The oil is present in sufficient quantity in the bark to allow it to be profitably distilled. The "suckers" from the stumps of the fallen trees grow rapidly, and produce an oil equal in value to that from the mature leaves, so that the process of distilling oil from the bark is not so wasteful as might at first sight appear. The bark oil, however, does not contain crystallised eudesmol, which substance is such a pronounced constituent in the leaf oil. The higher-boiling portions of the leaf-oil contained sufficient eudesmol to cause the third fraction to crystallise to a solid mass soon after distilling. Neither phellandrene nor cineol occur in the oil of this species, the small amount of terpene being dextro-rotatory pinene.

The results from a very large number of analyses on the oil of this species show that 60 per cent. of geranyl-acetate, saponifiable in the cold with two hours' contact with alcoholic potash, is the minimum at any time of the year. The oil of *E. Macarthuri* seems to follow the general rule for Eucalyptus oils by containing less terpene during the winter months, with a corresponding increase in ester. The oil from abnormal leaves contains even more ester than does that from the mature leaves, while that from leaves of two years old seedlings is also richer in geranyl-acetate than the oil from old leaves.

The crude oils are usually red in colour; as explained previously this red colour is due to the free acid in the oil attacking the iron of the still, and this, acting on the phenols, causes the oil to become red. The free geraniol in the oil was less when the ester content was high, and greater when the amount of ester





*EUCALYPTUS MACARTHURI*, H.D. & J.H.M.

CAMDEN WOOLLY BUTT.



1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

approached the minimum of 60 per cent. When the oil was distilled directly under atmospheric pressure, the ester was partly decomposed. (See the article in this work on "Geraniol and its acetic acid ester.")

**Oil from the Leaves.**—Leaves and terminal branchlets for distillation were obtained from Wingello, N.S.W., in October, 1900. The yield of oil was 0.12 per cent., 500 lb. of leaves and branchlets giving 9 ounces of oil. This appears

PLATE LXXVIII.



[Photo.]

[M. F. Connelly.]

**EUCALYPTUS MACARTHURI (D. & M.)**

PADDY'S RIVER BOX.

Near Wingello, N.S.W.

to be a minimum yield, as the average more nearly approaches 0.2 per cent. The crude oil was red in colour, and consisted principally of the ester geranyl-acetate, free geraniol, and eudesmol, with some pinene.

The crude oil had specific gravity at 15° C. = 0.9245; rotation  $a_D + 3.6^\circ$ ; refractive index at 20° = 1.4706, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 173.4, equal to 60.6 per cent. of geranyl-acetate. The dextro-rotation of the crude oil was partly due to the activity of the eudesmol.

On rectification, 1 per cent. distilled below 172° C. (corr.). Between 172–219°, 10 per cent. distilled; between 219–229°, 63 per cent. distilled; the

temperature then rapidly rose to  $266^{\circ}$ , a few drops only being obtained. Between  $266-282^{\circ}$ , 16 per cent. distilled, which fraction soon became solid. These fractions gave the following results:—

First fraction, sp. gr. at  $15^{\circ}$  C. = 0.8823; rotation not taken.

Second " " " = 0.9111; "  $a_D + 1.0^{\circ}$ .

Third " " " = 0.9511; " not taken.

An average sample of a June distillate from old leaves gave the following results:—Specific gravity at  $15^{\circ}$  C. = 0.9218; rotation  $a_D + 1.2^{\circ}$ ; saponification number = 191.8, representing 67.13 per cent. ester. Cold saponification during two hours' contact gave identical results. The crude oil was soluble in  $1\frac{1}{2}$  volumes 70 per cent. alcohol.

From very many analyses made since the first announcement in 1900, the following may be selected.

The oil distilled towards the end of July from old leaves, contained a larger amount of ester than the June oil, as the saponification number was 202, equal to 70.7 per cent. geranyl-acetate.

A sample of the oil distilled early in September, from old leaves, contained still more ester, the saponification number, in the cold with two hours' contact, being 214, equal to 74.9 per cent. geranyl-acetate.

The average ester content for a consignment of 100 pounds of the oil of this species, distilled from old leaves at various times during the year 1902, was 62.8 per cent. geranyl-acetate, from determinations made at the Museum during that year.

Analyses were also made with eight samples of the oil of this species which had been distilled at Wingello from old material during the year 1917. The average ester content for geranyl-acetate was 67.5.

The oil from the abnormal leaves contains even more geranyl-acetate than does that from the old leaves. This is shown from the following determination:—Trees had been felled at Paddy's River, N.S.W., for oil production, in April, 1902, and in the following March, the young growth from the stumps of the felled trees ("suckers") was distilled at the Museum. The yield of oil was 0.23 per cent. The ester value by cold saponification with two hours' contact was 221.4, equal to 77.5 per cent. geranyl-acetate.

This species readily lends itself to cultivation, and is now grown extensively at Emerald, Victoria, where the clippings from the young bushes have yielded up to 0.3 per cent. of oil. A sample of this oil which was distilled in the year 1913, from material twenty-two months old from the time of planting the seed, when analysed at the Museum, gave a saponification number by the cold treatment of 200.3, equal to 70.1 per cent. geranyl-acetate. The quality of this oil was excellent.

The vitality of this species is remarkable, and the continued reproduction of new material is quite equal to that of any other species of *Eucalyptus*.

**Oil from the Bark.**—The distillers who extracted an essential oil from the leaves of this species of *Eucalyptus* were generally acquainted with the odoriferous nature of the bark, and were desirous that the quality of the oil should be determined.

We are indebted to Mr. W. J. Quigg, of Wingello, N.S.W., for forwarding in November, 1915, the freshly-stripped bark for distillation. It had been obtained from fair-sized trees, and ranged in thickness up to  $1\frac{1}{2}$  inches. The odour of geranyl-acetate was distinctly noticeable on the freshly-cut edges, and when ground for distillation, had a very pleasant odour.

The yield of oil by steam-distillation from this ground bark was somewhat disappointing, as it did not exceed that obtainable from the mature leaves; but



the statement has been made that at certain times of the year, the yield is greater than that obtainable from the leaves at the same period.

The results of the investigation on the oil from the bark show it to be identical in composition with that obtainable from the leaves, so that no separation need be made for commercial purposes. With trees of fair size, it should be profitable to steam distil the bark for its oil, that is, if it be considered necessary to cut down the trees in the process of manufacture. The growth of "suckers" from the stumps of the felled trees is, however, somewhat rapid, so that new material would soon be available, and, as shown above, an excellent oil is obtainable from this young foliaceous growth.

The bark was chopped into small pieces, coarsely ground in a mill, and steam-distilled. The yield of oil was equal to 0.12 per cent.

The crude oil was of a light amber colour, and had a distinct odour of geranyl-acetate. It gave the following results:—

|                                              |     |     |     |           |
|----------------------------------------------|-----|-----|-----|-----------|
| Specific gravity at 15° C. ...               | ... | ... | ... | = 0.9214. |
| Optical rotation $\alpha_D$ ...              | ... | ... | ... | + 1.2°.   |
| Refractive index at 20° C. ...               | ... | ... | ... | = 1.4718. |
| Soluble in 1.2 volumes 70 per cent. alcohol. |     |     |     |           |

The optical activity of the oil was due to the presence of a small quantity of dextro-rotatory pinene. The stearoptene eudesmol, which is a constant constituent in the leaf oil, does not appear to be present in the bark oil.

The saponification number for the esters in the cold with two hours' contact was 169.5, equal to 59.3 per cent. geranyl-acetate.

A portion of the oil was then acetylated in the usual way. The saponification number with this acetylated oil in the cold was 198.8, equal to 69.6 per cent. of ester. The saponification number had thus increased by 29.3, so that the free geraniol in the oil was 8 per cent.

A sample of crude oil from the bark of this species distilled in October, at Wingello, by Mr. W. J. Quigg, was also investigated at the Technological Museum. It contained a larger amount of ester than did the oil distilled by us, and had the following characters:—

|                                              |     |     |     |           |
|----------------------------------------------|-----|-----|-----|-----------|
| Specific gravity at 15° C. ...               | ... | ... | ... | = 0.9099. |
| Optical rotation $\alpha_D$ ...              | ... | ... | ... | + 1.4°.   |
| Refractive index at 20° ...                  | ... | ... | ... | = 1.4648. |
| Soluble in 1.2 volumes 70 per cent. alcohol. |     |     |     |           |

The saponification number for the ester in the cold with two hours' contact was 195, equal to 68.2 per cent. geranyl-acetate.

The saponification number for the acetylated oil, also in the cold, was 224, equal to 78.4 per cent. of ester, an increase in the saponification number of 29, representing about 8 per cent. of free geraniol in the crude oil.

A commercial sample of the bark oil of this species, presented to the Museum by De Meric Ltd., George-street, Sydney, had the following characters:—

|                                              |     |     |     |           |
|----------------------------------------------|-----|-----|-----|-----------|
| Specific gravity at 15° C. ...               | ... | ... | ... | = 0.9218. |
| Optical rotation $\alpha_D$ ...              | ... | ... | ... | + 1.2°.   |
| Refractive index at 20° ...                  | ... | ... | ... | = 1.4711. |
| Soluble in 1.2 volumes 70 per cent. alcohol. |     |     |     |           |

The saponification number in the cold with two hours' contact was 169, equal to 59.2 per cent. geranyl-acetate.

This *Eucalyptus* is one of the very few species of the genus from which an essential oil can be distilled from the bark, and, so far as at present known, it is the only *Eucalyptus* bark of commercial value for oil production.

## 170. *Eucalyptus aggregata*.

(H.D. & J.H.M., Proc. Linn. Soc., N.S.W., 1899, p. 614, pl. XLIX.)

### Black Gum.

**Systematic.**—Usually small, gnarled trees, with a trunk of 12 to 18 inches or even 2 feet in diameter. Abnormal leaves quite glabrous, oval to nearly oblong, strictly opposite, up to 1 inch long, the margins undulate, mucronate, with a short point. Normal leaves lanceolate, undulate, equally green on both sides, scarcely shining, on the average probably  $4\frac{1}{2}$  inches long and 1 inch broad; intramarginal vein considerably removed from the edge, other veins few, but conspicuous, very oblique. Buds usually four to six in the umbel; operculum and calyx tube about equal, and both tapering towards a point, the operculum being nearly conical.

**Fruit.**—Hemispherical in shape, small and sometimes, owing to the shortening of the pedicels, so clustered together as to form a dense head, hence the specific name; with a well defined sharp-domed rim; three or four well exerted valves; not exceeding  $\frac{3}{16}$  of an inch in diameter.



**Habitat.**—Alluvial flats, following watercourses or depressions. Usually found in damp situations. Braidwood and Rydal, New South Wales.

**REMARKS.**—In the Proc. Roy. Soc., Tasmania, 1914, p. 30, J. H. Maiden claims that this is identical with *E. Rodwayi*, a determination quite at variance with data we have obtained from each.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Fagan's Creek, Little River, Braidwood, N.S.W., in October, 1898. The yield of oil was small, 394 lb. of leaves and branchlets giving only  $2\frac{1}{2}$  oz. of oil, equal to 0.04 per cent. The crude oil was light orange-brown in colour, was very mobile, and had a somewhat rank odour, with but little resemblance to ordinary Eucalyptus oil. It contained a somewhat large amount of pinene, which was dextro-rotatory; this terpene was proved by the formation of the nitrosochloride, and other tests. Cineol and phellandrene both appeared to be absent. The principal constituent was an ester, the alcohol of which was amyl-alcohol, combined with a solid acid, which has been named eudesmic acid.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.956; refractive index at  $20^{\circ}$  = 1.5005; and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 112.2.

On rectification, 1 per cent. distilled below  $156^{\circ}$  C. (corr.). Between  $156$ – $164^{\circ}$ , 26 per cent. distilled; between  $164$ – $245^{\circ}$ , 12 per cent. came over, and between  $245$ – $292^{\circ}$ , 22 per cent. distilled. The remainder when removed from the still became crystalline on cooling. The fractions gave the following results;—

|                 |                            |           |                                 |
|-----------------|----------------------------|-----------|---------------------------------|
| First fraction, | sp. gr. at $15^{\circ}$ C. | = 0.8660; | rotation $a_D + 23.5^{\circ}$ , |
| Second          | "                          | = 0.8769; | " not taken,                    |
| Third           | "                          | = 0.9868; | "                               |





*W. Marshall del*

**EUCALYPTUS AGGREGATA, H.D. & J.H.M.**





Material of this species for distillation was obtained at Rydal, N.S.W., in September, 1909. The yield of oil was 0.038 per cent. The oil was in general agreement with that from Fagan's Creek, and contained a considerable amount of ester, the alcohol of which was amyl, but the solid acid did not agree with the characters obtained with eudesmic acid. It is thus possible that two esters occur in the oil of this species. Efforts were made to decide this point, and material for distillation was collected at Rydal in January, 1920, but unfortunately, at this time of the year, sufficient oil was not present to separate from the distilled water.

The Rydal oil had specific gravity at 15° C. = 0.9474; rotation  $a_D + 11.2^\circ$ , and refractive index at 20° = 1.4977. The saponification number for the esters and free acid was 119.5.

The alcohol of the ester was separated, oxidised to valeric acid, and the silver salt of this prepared; the metallic silver thus obtained was 51.74 per cent., which is almost a theoretical result. It was thus evident that the alcohol of the ester was amyl.

The solid acid when purified was in paraffin-like leaflets and melted at 76.5° C.; by titration with a deci-normal solution of sodium hydrate, a molecular value 135.6 was obtained. It was a saturated acid, and when treated with manganese dioxide and sulphuric acid gave an odour of benzyaldehyde. This evidence points to this acid being phenyl-acetic acid. Unfortunately the species produces almost the least oil of any, so that sufficient for investigation was difficult to procure.

## 171. *Eucalyptus Staigeriana*.

(F.v.M., in Edit. Bailey in Synopsis Queensland Flora, 176, 1883.)

**Lemon-scented Ironbark.**

**Systematic.**—A medium-sized tree with glaucous foliage. Leaves ovate to lanceolate, usually under 5 inches long, obtuse, sometimes shortly pointed; venation fairly distinct, especially on the under surface, intramarginal vein looped, usually well removed from the edge, but sometimes quite close, lateral veins spreading, inclined at about 45° to the mid-rib. Peduncles axillary or lateral, 4 to 6 lines long, each with three to six flowers, often in terminal panicles. Buds glaucous; calyx tube semi-ovate, contracted to a slender pedicel; operculum conical.

**Fruit.**—Semi-ovoid to hemispherical, on slender pedicels; rim thin; valves slightly exserted; about  $2\frac{1}{2}$  lines long and 2 lines in diameter.



*Perhaps the two fruits closest in morphological affinity are E. intertexta (some forms) and E. melliodora.*

**Habitat.**—Palmer River, Queensland.

**ESSENTIAL OIL.**—The oil of this species of *Eucalyptus* is abnormal, as it contains the aldehyde citral in some quantity. The oil was referred to by Schimmel & Co., in the year 1888 (Semi-Annual Report), the specific gravity being recorded as 0.889 and the boiling point from 170–230° C.

In the first edition of this work this Eucalypt does not appear, because it was not possible at that time to procure material for distillation, as the species grows in country not easy of access. Efforts since made to procure material for investigation have been successful, and through the kindness of the late Mr. Ingham, the Queensland distiller, and Mr. J. L. Adams, Chemist, of Cooktown, leaves were collected on the Palmer River, Queensland. They had to be brought many miles by carrier to the nearest railway station, then forwarded to Cooktown, and afterwards by sea to Sydney.

The principal terpene occurring in the oil of this species was lævo-rotatory limonene, and both pinene and phellandrene appeared to be absent. Cineol could not be detected. The oil had some resemblance in its physical properties to lemon oil, the optical activity, however, being in the reverse direction. The amount of citral was not great, although more abundant than in lemon oil, but does not correspond in this respect to the oil of *Backhousia citriodora* or even to that obtained from *Leptospermum Liversidgei* (Proc. Roy. Soc. N.S.W., December, 1905). The amount of free alcohol (most probably geraniol) was somewhat large, and the secondary odour of the oil, when freed from the aldehydes, resembled that of geraniol very markedly. The ester was most probably wholly geranylacetate, particularly as this substance occurs plentifully in Eucalyptus oils. The high refractive index of the higher-boiling portion indicated that the sesquiterpene was also present, although the results do not allow room for much of that constituent. The crude oil was of a light lemon colour, was mobile, and very aromatic, the citral and free geraniol combining to give it a pleasant and refreshing odour, without the slightest resemblance to that of ordinary Eucalyptus oil as known in pharmacy.

The material, which consisted of leaves and terminal branchlets, had been more carefully collected than would be the case commercially, and as the leaves were quite dry, the yield may be considered a maximum one. Thirty-one ounces of oil were obtained from 78 lb. of material, equal to 2.48 per cent. It may reasonably be supposed that the oil of this species will eventually become of some commercial importance when better known. Comparative tests for flavouring purposes with the rectified product compared very favourably with the best lemon oil, both for culinary purposes and in the manufacture of lemonades.

The crude oil had specific gravity at 15° C. = 0.8715; rotation  $a_D$  — 37.53°; refractive index at 20° = 1.4814, and was soluble in 8 volumes 80 per cent. alcohol. Saponification number for esters and free acid was 8.6.

On rectification, only a few drops came over below 175° C. (corr.). Between 175–193°, 65 per cent. distilled; between 193–265°, 23 per cent. distilled; at higher temperature the distillate was quite acid. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.857; refractive index at 20° = 1.4774.

Second " " " " = 0.8888; refractive index at 20° = 1.4822.

The portion boiling below 193 was again fractionated. Nothing came over below 175° C. (corr.), but 40 per cent. of the fraction distilled between 175–177°, and 23 per cent. between 177–179°; between 179–184° 17 per cent. distilled. These fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.852; rotation  $a_D$  — 66.2°; refractive index at 20° = 1.4764.

Second " " " " = 0.8585; rotation  $a_D$  — 64.8°; refractive index at 20° = 1.4791.

Third " " " " = 0.8586; rotation  $a_D$  — 60.9°; refractive index at 20° = 1.4799.





*W. Marshall, del.*

**EUCALYPTUS STAIGERIANA, F.V.M.**  
LEMON SCENTED IRONBARK.



The tetrabromide was formed in the usual way with the fraction distilling at 175–177°, and when purified melted at 104–105° C. It thus appears that the terpene present in the oil of this *Eucalyptus* was almost entirely lævo-rotatory limonene, and that over 60 per cent. of the oil consisted of that substance.

An aldehyde determination on the crude oil, using a 30 per cent. solution of sodium bisulphite, gave an absorption equal to 16 per cent. of citral. This aldehyde when purified formed the characteristic naphthocinchonic acid by Doebner's reaction, the product melting at 198° C.

The non-aldehydic oil, which was quite aromatic, had a secondary odour of geraniol. It had specific gravity at 15° C. = 0.8710; rotation  $\alpha_D$  — 46.8°; refractive index at 20° = 1.4802.

The saponification number for the esters and free acid in the non-aldehydic oil was 28.3, or 9.9 per cent. of ester, if calculated as geranyl-acetate, equal to 8.3 per cent. in the original oil.

A portion of the non-aldehydic oil was acetylated in the usual way, when the saponification number had risen to 78.5, representing 13.8 per cent. free alcohol, calculated as geraniol, or 11.6 per cent. on the original oil.

The results of this investigation were originally published in the *Pharmaceutical Journal*, London, March, 1906.

## 172. *Eucalyptus patentinervis*.

(R.T.B., Proc. Linn. Soc., N.S.W., 1899, p. 602, t. XLV.)

Half Mahogany.

**Systematic.**—A good-sized tree, as far as seen, with a bark similar to that of some species of Pines. Ultimate branchlets angular. Abnormal leaves ovate, shortly acuminate, lanceolate, thin, almost membranous, petiole slender, from 1 to 2 inches long; venation prominent, intramarginal vein removed from the edge. Normal leaves lanceolate-falcate, coriaceous, acuminate, almost 1 foot long in some cases, not shining, colour uniform on both sides, petiole rather slender, channelled above; venation very distinct in the coast trees, but finer in the inland ones, lateral veins very prominent and spreading, curved, numerous, the intramarginal vein removed from the edge. Peduncles axillary, about 1 inch long, flattened, bearing about ten fairly large flowers. Calyx tube occasionally angular, 6 lines long; operculum about as long as the calyx, conical, sometimes concave below the summit.

**Fruit.**—Large, hemispherical, to pyriform, on a pedicel of about 4 lines in length; rim quite 1 line broad; valves prominently exserted, acute or occasionally obtuse as depicted; nearly 3 lines long, 4 lines in diameter.

*These are very much like an enlarged form of E. resinifera, but more bell-shaped.*

**Habitat.**—Ballina, Bungwahl, Belmore, Milton, Ashfield, Sassafras, New South Wales.





**REMARKS.**—The common name of "Half Mahogany" might lead one to place this species under *E. resinifera*, Sm., and, no doubt, it may have been so classed in herbaria, but it differs from it in several features. The leaves of *E. resinifera* have "numerous fine, close, parallel, and almost transverse veins, sometimes scarcely conspicuous, the intramarginal one close to the edge." This species has a venation more like that of *E. terebinthifolia*, Sm., than of *E. resinifera*, Sm. The transverse veins are oblique, prominent, and spreading, and the intramarginal one removed from the edge, particularly in the abnormal leaves. The venation, therefore, shows no connection with *E. resinifera*, Sm., nor does it with *E. pellita*, F.v.M. From this latter species it also differs in the shape and size of the calyx tube, and also in the fruits. The timber is specifically light, and of a pale-red colour. The odour is quite unlike that exhaled from any other Eucalyptus. The fruits are characteristic, and the bark is close and compact. It is well distributed in the Coast district, extending from the Queensland border to Illawarra. Since this species was described, we have seen a specimen in the National Herbarium, Melbourne, labelled *E. Kirtoni*, by Baron von Mueller, which much resembles, and, no doubt, is this species; but, as no proper description of *E. Kirtoni* was ever published, and in view of the scientific data now recorded we have decided to let our name stand, purely for the sake of scientific precision.

Mr. Maiden joins issue with us in retaining this name, but admits (Crit. Rev. Euc. Vol. iii., p. 200) that "Mueller's description is unsatisfactory as measured by modern standards."

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Belmore, N.S.W., in February, 1900. The yield of oil was 0.26 per cent. The crude oil was orange-brown in colour, was very mobile, and had a secondary odour resembling that of citral. The presence of this aldehyde in the oil was proved by extracting it with acid sodium sulphite, and preparing its characteristic naphthocinchonic acid. Phellandrene could not be detected, nor was conclusive proof obtained of the presence of pinene. The low specific gravity of the first fraction, its high lævo-rotation, together with its boiling point, suggested the presence of limonene, but attempts to form the characteristic tetrabromide were not successful, nor were the reactions for cymene obtained. At present the identity of this terpene remains undecided. Cineol could not be detected in the oil. A good quantity of the sesquiterpene was present, 20 per cent. distilling between 260–270° C. Free alcohols occur, and these gave the oil a pleasant odour. Esters were not pronounced.

The crude oil had specific gravity at 15° C. = 0.8735; rotation  $a_D$  — 15.2°; refractive index at 20° = 1.4891, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 6.2.

A portion of the oil was acetylated in the usual way when the saponification number had risen to 63.3, suggesting the presence of nearly 16 per cent. of free alcohol, if calculated for the  $C_{16}H_{18}O$  molecule.

On rectification, 2 per cent. distilled below 174° C. (corr.). Between 174–179°, 34 per cent. distilled; between 179–245°, 27 per cent. came over, and between 245–273°, 24 per cent. distilled. Thus 13 per cent. remained in the still, boiling above 273° C. The fractions gave the following results:—

First fraction, sp. gr. at 15° C. = 0.8519; rotation  $a_D$  — 23.4°.

Second " " " = 0.8600; " not taken.

Third " " " = 0.9035; " "

The above sample was stored in the dark, and in November, 1919, was again analysed. Very little alteration had taken place during the nineteen years the oil had been kept, except that the specific gravity had increased a little, and the optical rotation had diminished about 5 degrees. 47 per cent. distilled below 190° C. The crude oil and the rectified portion gave the following results:—

Crude oil, sp. gr. at 15° C. = 0.8832; rotation  $a_D$  — 9.5°; refractive index at 20° = 1.4891.

Rectified portion " " = 0.8544; rotation  $a_D$  — 22.4°; refractive index at 20° = 1.4807.

The cineol was determined by the resorcinol method in the rectified portion; when calculated for the crude oil, the result was only 1 per cent. It is thus evident that cineol was practically absent in the oil of this species, as were also other absorbable bodies,



EUCALYPTUS PATENTINERVIS, R.T.B.  
A MAHOGANY





## 173. *Eucalyptus citriodora*.

(Hook., Mitch., Trop. Austr., 235.)

**Citron-scented Gum.**

**Systematic.**—A large tree with a smooth, whitish bark. Leaves lanceolate, up to 6 inches long and 9 lines wide, acuminate, not shining; venation finely marked, lateral veins numerous, oblique, parallel or slightly spreading, intra-marginal vein very slightly removed from the edge, which is more or less irregular. Flowers numerous in axillary panicles. Calyx tube hemispherical to slightly cylindrical, about 2 lines in diameter, pedicel under 2 lines long; operculum hemispherical, umbonate.

**Fruit.**—Ovoid, truncate, contracted at the edge; rim thin; valves opening downwards; under 4 lines in diameter and 6 lines long.

*Only separated with difficulty from E. maculata.*



**Habitat.**—North coast district of Queensland.

**REMARKS.**—The above is the locality as at present known of this species. Sir T. Mitchell collected his specimens far inland, at Beebury Creek, Mantua Downs, and "Sir William Hooker named this Eucalypt (although without flower or fruit) from the deliciously fragrant lemon-like odour, which exists in the dry as well as in the recent state." (Mitch. Trop. Aust. 235.) The term "Citron-scented Gum" is now applied to a Coast tree with a smooth white bark, and is largely cultivated. It is not the only *Eucalyptus* possessing an aroma of this character in its oil, as this also occurs in the North Queensland "Ironbark," *E. Slaigeriana*, F.v.M. Whether Mitchell's tree is botanically identical with that on the coast and the one to which the name is now applied remains to be proved, for, as stated above, the species was established on the leaves and chemical constituents alone.

**ESSENTIAL OIL.**—The oil of this species of *Eucalyptus* consists almost entirely of the aldehyde citronellal, with from 5 to 10 per cent. of other bodies, including a small quantity of ester, a little alcohol, perhaps geraniol or citronellol, and a very small quantity of a terpene. It has no resemblance to that distilled from the leaves of *E. maculata*.

This *Eucalypt* is essentially a Queensland one, growing quite extensively in the Gladstone District, but it readily lends itself to cultivation in other parts, and grows quite well in the Sydney District. The species is quite stabilised, so that the oil always shows comparative constancy, no matter where the trees are grown. It also shows considerable vitality, and we have been informed by a gentleman who knows the district well, that on the Herberton Range to the north of Cairns there are many hundreds of acres where *E. citriodora* grows plentifully. When he was there the trees had been cut down for mining purposes, but a great quantity of "suckers" had come up, and consequently an abundance of leaf was available. He distilled oil from this material and found it of excellent quality.

We were unable to obtain leaves from Queensland for distillation purposes, but have investigated the oil commercially distilled there. It was found to be in agreement with the oil we distilled from a cultivated tree in Sydney. That the constitution of the oil from cultivated trees is similar to that distilled from material growing in its native habitat, can be seen from the results of the analyses we submit herewith.

The cultivated tree from which the leaves and terminal branchlets were obtained for distillation was growing on land resumed by the Government upon which to erect the new Sydney Railway Station; it was collected in February, 1902. The yield of oil was 0.6 per cent. The oil was but little coloured and had the citronellal odour characteristic of the oil of this species.

The crude oil had specific gravity at 15° C. = 0.864; rotation  $a_D$  — 1.0°; refractive index at 20° = 1.4594, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters and free acid was 7. An aldehyde determination carried out in the ordinary manner showed 91 per cent. absorption; this was assumed to be wholly citronellal.

Only a very small amount of a terpene could have been present, and both cineol and phellandrene were absent.

---

A sample of the commercially distilled oil was forwarded to the Museum in 1909, by Mr. F. D. Ferguson, who had distilled it at Gladstone, Queensland. It was but little coloured; had specific gravity at 15° C. = 0.8697; rotation  $a_D$  + 1.7°; refractive index at 20° = 1.4596, and was soluble in 1½ volumes 70 per cent. alcohol. An aldehyde determination gave a result of 92 per cent. of citronellal.

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In October, 1919, material was collected for distillation from three-year old plants, grown from seed by Mr. E. Cheel, at Ashfield, near Sydney. The yield of oil was 1 per cent. The product was but little coloured, and was an excellent sample of the oil of this species. It had specific gravity at 15° C. = 0.8657; rotation  $a_D$  — 1.1°; refractive index at 20° = 1.4515, and was soluble in 1½ volumes 70 per cent. alcohol. An aldehyde determination showed that 95 per cent. was absorbed.

A sample of the oil of this species distilled at the Dunolly Farm in Victoria, was examined by Mr. J. C. Umney (Pharm. Journ. IV. 3, p. 200.). It had specific gravity at 15° C. = 0.8809; rotation  $a_D$  — 1°; and contained 90 per cent. of aldehyde.

The yield of oil from this species varies somewhat according to the age of the material distilled, but under the most favourable conditions it should be about 1 per cent. In the year 1910, Mr. Ferguson obtained a yield averaging 0.89 per cent. from 80 tons of material.

## 174. *Eucalyptus Marsdeni*.

(Cuthbert Hall, in Proc. Linn. Soc., N.S.W., 1918, p. 747.)

**Systematic.**—A tree 30 feet high in specimen observed, and probably would attain a height of 60 to 80 feet when fully grown. Bark smooth on the upper branches, laminated with an ochreous deposit on the outer surface of each layer, inner bark very hard and compact. Abnormal leaves alternate narrow-lanceolate, falcate, petiolate, acuminate, thin, and shining, up to 6 inches long. Normal leaves lanceolate, acuminate, falcate, thin, usually under 6 inches long; venation less pronounced in older leaves, intramarginal vein fairly close to the edge, looped,

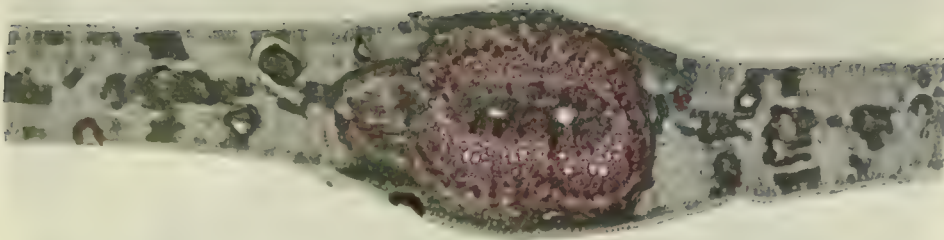




*EUCALYPTUS CITRIODORA*, HOOK.  
CITRON SCENTED GUM.



70 1980  
1980 1980



A section showing portions of the leaf blade adjoining the mid-rib, which is of a very compact nature. The woody fibres form almost a complete circle around the bicollateral bundle which has the unusual feature of two ducts in the centre—a character also found in the Bloodwoods, as shown in *E. corymbosa* (Plate XVI). The reagents used in mounting the section seem to have hardened the contents of the oil glands rather than dissolved them, as in the case of almost all other species.

x 60.

EUCALYPTUS CITRIODORA. Hook.

UNIV. OF  
California





lateral veins distant, spreading oblique, inclined at an angle of  $30^\circ$  or less to the mid-rib. Peduncles angular, 5 lines long, bearing umbels of six to nine flowers. Calyx tube 2 lines long, turbinate, contracted to a short pedicel; operculum hemispherical, shortly pointed.

**Fruit.**—Hemispherical on short slender pedicels; rim domed; valves slightly exserted;  $2\frac{1}{2}$  lines long and 3 lines in diameter.



*E. Rossii* or *E. maculosa* are perhaps the nearest affinities morphologically.

**Habitat.**—Toongabbie, N.S.W.

**ESSENTIAL OIL.**—Material of this species was obtained from near Parramatta, N.S.W., and forwarded for distillation by Dr. Cuthbert Hall. The yield of oil was 0.7 per cent.

The crude oil was almost as viscous as castor oil, and had little resemblance to the ordinary Eucalyptus oils of commerce. It contained a considerable amount of the sesquiterpene, and in this respect resembled the oil of *E. nova-anglica* and a few others. The oil at our disposal did not permit of complete analysis, but it is possible that the active terpene was dextro-rotatory pinene. Cineol was practically absent, and phellandrene could not be detected. The oil was but little coloured and had a not unpleasant odour. The phenols gave the reaction for tasmanol, but the crystalline phenol australol appears to be the most abundant.

The crude oil had specific gravity at  $15^\circ$  C. = 0.9469; rotation  $\alpha_D + 4.8^\circ$ ; refractive index at  $20^\circ$  = 1.4989, and was insoluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was only 2, so that esters were practically absent. Some of the oil was distilled, but only 2 per cent. came over below  $200^\circ$  C.; traces of cineol could be detected in this portion, the remainder consisting largely of the sesquiterpene.

## 175. *Eucalyptus ligustrina*.

(DC., in Prod., vol. iii, p. 219.)

**Systematic.**—A low shrub, a few feet in height. Abnormal leaves ovate or oblong, thick and mucronate, about  $\frac{1}{2}$  inch in length, shortly petiolate or alternate. Normal leaves lanceolate, thick, coriaceous, shining, acuminate, usually falcate and unequal at the base; venation not prominent, intramarginal vein not far removed from the edge, lateral veins inclined at about  $30^\circ$  to the mid-rib. Flowers sessile in heads of about nine on axillary or lateral, angular peduncles, about 3 lines long. Calyx tube under 2 lines long, conoidal, twice as long as the scarcely pointed, semi-ovoid operculum.

**Fruit.**—Compressed, globular; rim narrow, flat or somewhat convex, reddish; valves scarcely exserted; about 2 lines long and 3 lines in diameter.



**Habitat.**—Blue Mountains, New South Wales.

**REMARKS.**—Our investigations show that this species has little or no connection with *E. eugenoides*, and we are inclined to place the data under Cunningham's *E. oleifolia*. Maiden, "Critical Revision Genus Eucalyptus," Vol. 1, p. 234, places this latter and De Candolle's species, *E. ligustrina* under *E. eugenoides*, var. *nana*, but later, Roy. Soc. N.S.W., Vol. 52, p. 502, 1918, places it under *E. ligustrina*, and states that he is unable to distinguish the former (*E. ligustrina*) from some of the latter (*E. eugenoides*, var. *nana*). This plant might be described as dimorphous, for one form appears to have been described by A. Cunningham under *E. oleifolia* (1822), whilst the other by De Candolle under *E. ligustrina*, and as the former was described first, we think that name should stand by priority, but in order not to further increase the terminology of the genus we fall into line with Mr. J. H. Maiden.

**ESSENTIAL OIL.**—Leaves and terminal branchlets were obtained for distillation from Wentworth Falls, N.S.W., January, 1920. The yield of oil, which represents the whole obtained, was 0.12 per cent. The oil was of a light-orange colour, and had an aromatic odour, not well defined. The constituents detected were pinene, cineol, geranyl-acetate, geraniol, and eudesmol, together with the sesquiterpene. The principal constituent was crystallised eudesmol. Phellandrene does not occur.

The crude oil had specific gravity at 15° C. = 0.9499; rotation  $a_D + 22.4^\circ$ ; refractive index at 20° = 1.4974, and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters was 9, both by the hot and cold methods; this represents 3.15 per cent. calculated as geranyl-acetate. After acetylation, the saponification number was 122.28, while in the cold with two hours' contact, it was 22.8. This result represents 42.6 per cent. free eudesmol, and 3.8 per cent. free geraniol.

On rectification, practically nothing came over below 174° C. (corr.). Between 174–193°, 12 per cent. distilled; between 193–214°, 12 per cent. came over, and between 273–300°, 65 per cent. distilled, leaving 10 per cent. of residue. The fractions gave the following results:—

|                             |                             |                               |                                   |
|-----------------------------|-----------------------------|-------------------------------|-----------------------------------|
| First fraction,             | sp. gr. at 15° C. = 0.8725; | rotation $a_D + 8.0^\circ$ ;  | refractive index at 20° = 1.4732. |
| Second     ,,     ,,     ,, | = 0.8869;                   | rotation $a_D + 10.4^\circ$ ; | refractive index at 20° = 1.4774. |
| Third     ,,     ,,     ,,  | = 0.9655;                   | rotation $a_D + 28.4^\circ$ ; | refractive index at 20° = 1.5064. |

The cineol was determined by the resorcinol method in the portion distilling below 193°; the result was 5 per cent. when calculated for the crude oil.

The above figures give the results obtained with the liquid portion, which represented one half of the total oil product. The other half, which distilled later and under a greater pressure of steam, consisted principally of eudesmol and the sesquiterpene. From this portion, the pure eudesmol was prepared; it melted at 80° C., and the specific rotation was  $[a]_D + 30^\circ$ , in a 10 per cent. chloroform solution at 21° C.

## 176. *Eucalyptus apiculata*.

(R.T.B. & H.G.S., in Euc. and their Ess. Oils, 1st Edit., 1902.)

**Systematic.**—A shrub 6 to 8 feet high. Leaves narrow, lanceolate, with a pronounced recurved point, erect, thinly coriaceous, shining, 4 to 5 inches long, petiole about 2 lines long; venation quite hidden beneath the cuticle, which, when removed, shows the lateral veins to be oblique and spreading, and identical in disposition with those of *E. dives*, Schau., and others of the "Peppermint"



group of Eucalypts. Peduncles axillary, about 5 lines long, terete or slightly flattened, with five to seven flowers in the umbel. Calyx hemispherical; operculum hemispherical, shortly acuminate, 3 lines in diameter.

**Fruit.**—Might be described as hemispherical or pilular, but contracted at the rim, which is either countersunk or flat; 3 to 4 lines in diameter.



*These are very close in form to E. stricta.*

**Habitat.**—Berrima, Mittagong, New South Wales.

**REMARKS.**—This tree, both in the field and herbarium material, has so much the facies of *E. stricta*, Sieb., that it was considered by us at first, and without any hesitation, as identical with that species. The differences, however, in the constituents of their respective oils—differences such as could not be due to soil or climate—caused us to make a further search for morphological characters, such as the oil constituents seemed to indicate. The presence of the peppermint constituent in this species also led us to look for a venation similar to that of *E. dives*, Schau., and others containing this particular property, and such was found when the cuticle of the leaf was removed. By a similar treatment, the leaf of *E. stricta* was found to have a venation corresponding to *E. Bridgesiana*, R.T.B., and others of the richer cineol-yielding Eucalypts. It is, therefore, upon the presence of these characters and oil constituents that the two species, *E. stricta*, Sieb., and *E. apiculata*, are separated.

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Berrima, N.S.W., in May, 1899. The yield of oil was 0.7 per cent. The crude oil was of a light orange-brown colour, and had a strong peppermint-like odour. Only a small amount of cineol could be detected. Pinene was present, but phellandrene was absent. The peppermint constituent was present in some quantity, and 18 per cent. came over between 228–240° C.

The crude oil had specific gravity at 15° C. = 0.9112; rotation  $a_D$  — 7.8°; refractive index at 20° = 1.4877; and was soluble in 1 volume 80 per cent. alcohol. The saponification number for the esters and free acid was 8.7.

On rectification, 2 per cent. distilled below 170° C. (corr.). Between 170–185°, 38 per cent. distilled; between 185–228°, 37 per cent. came over, and between 228–240°, 18 per cent. distilled. These fractions gave the following results:—

|                 |                   |           |                |         |
|-----------------|-------------------|-----------|----------------|---------|
| First fraction, | sp. gr. at 15° C. | = 0.8861; | rotation $a_D$ | + 4.3°. |
| Second          | "                 | = 0.9045; | "              | + 1.5°. |
| Third           | "                 | = 0.9420; | "              | + 4.4°. |

It will be noticed that the three fractions were all dextro-rotatory, but that the crude oil was lævo-rotatory. The reason for this peculiarity was the alteration which takes place in the optical activity of the piperitone when submitted to direct distillation.

Material of this species for distillation was also obtained from Berrima, N.S.W., in September, 1899, in order to test the constancy of constituents. The oil was found to be practically identical with that of the previous consignment, the constituents were similar, and present in about the same amounts. The specific gravity of the crude oil was 0.9056, and the optical rotation  $a_D$  — 8.4°. The crude oil formed a clear solution with 1 volume 80 per cent. alcohol.

Material of this species was also obtained for distillation from Mittagong, N.S.W., in July, 1901. The oil was in agreement with those of the material from Berrima. A portion of this oil was acetylated in order to determine if alcohols



were present; the saponification number of the acetylated oil was 39.74, whilst that for the original oil was 10.05; the increase was thus 29.69, due to the free alcohols present. This result represents about 5 per cent. of free alcohol, considered as  $C_{10}H_{18}O$ .

The above samples were mixed together, stored in the dark, and in December, 1919, the oil was again analysed. It had specific gravity at  $15^{\circ}C.$  = 0.9138; rotation  $a_D$  —  $10.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4864; ketone estimation 38 per cent.

On rectification, under reduced pressure, the following results were obtained:—

|                                                  |     |              |
|--------------------------------------------------|-----|--------------|
| Below $100^{\circ}C.$ at 10 millimetres pressure | =   | 60 per cent. |
| Between $100-108^{\circ}$                        | „ „ | = 23 „       |
| Between $108-128^{\circ}$                        | „ „ | = 5 „        |
| Between $128-152^{\circ}$                        | „ „ | = 11 „       |

The first fraction had specific gravity at  $15^{\circ}C.$  = 0.8818; rotation  $a_D$  —  $1.8^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4818; it contained both cineol and piperitone.

On repeated fractionation, a substance was obtained having specific gravity at  $15^{\circ}C.$  = 0.864; rotation  $a_D$  +  $11.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4752; it was mostly pinene and gave a nitrosochloride, melting at  $104^{\circ}$ .

The second fraction ( $100-108^{\circ}$ ) had specific gravity at  $15^{\circ}C.$  = 0.940; rotation  $a_D$  —  $31.4^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4854; ketone absorption 91 per cent. On reduction with sodium-amalgam it gave the crystalline body melting at  $142^{\circ}$ . This fraction thus consisted almost entirely of piperitone. The third fraction ( $108-128^{\circ}$ ) differed but slightly from the second fraction, and contained 90 per cent. piperitone.

The fourth fraction consisted of piperitone, the sesquiterpene, and some alcoholic bodies.

To determine the approximate amount of the alcohols, the piperitone was removed by treatment with a neutral sodium sulphite solution; the remainder had specific gravity at  $15^{\circ}$  = 0.8971; rotation  $a_D$  +  $1.6^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4876; saponification number 12.4; after acetylation it was 36.7, equal to 10 per cent. of a  $C_{15}H_{25}OH$  alcohol. This sesquiterpene alcohol was probably the liquid form of eudesmol.

A portion of the original oil was rectified under atmospheric pressure, when 42 per cent. distilled below  $190^{\circ}C.$  This portion had specific gravity at  $15^{\circ}C.$  = 0.8800; rotation  $a_D$  +  $1.0^{\circ}$ ; and refractive index at  $20^{\circ}$  = 1.4811.

The cineol was determined in this fraction by the resorcinol method; when calculated for the crude oil, the result was 8 per cent.

## ADDENDUM.

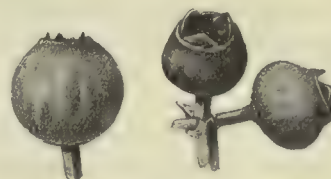
### 177. *Eucalyptus Baileyana*.

[F.v.M., *Fragm.* xl, p. 37 (1878).]

**Rough Stringybark.**

**Systematic.**—A large tree, reaching a height of 150 feet, and a diameter of 4 feet. Bark fibrous, persistent on the branches as well as the trunk. Branchlets angular. Abnormal leaves ovate to ovate-lanceolate, sometimes cordate at the base, mucronate, often inclined to be acuminate or even rounded, petiolate, up to 6 inches long and  $2\frac{1}{2}$  inches broad, margin undulate, recurved, under surface much paler in colour, branchlets and under surface of leaves covered with rusty-coloured, stellate hairs. Normal leaves lanceolate, often falcate, strongly acuminate, uncinat, under side decidedly paler in colour than the upper surface, which is somewhat shining, about 5 inches long and 1 inch broad; venation distinct, lateral veins fine, numerous, more or less parallel, forming an angle of  $45^\circ$  or more with the mid-rib, intramarginal vein close to the edge. Peduncles lateral or axillary, flattened, about 1 inch in length, bearing umbels of five to seven flowers. Buds pyriform, on flattened or angular pedicels 2 to 4 lines long; operculum hemispherical, umbonate.

**Fruit.**—Globular, jar-shaped; contracted at the rim, rim thin, grooved; valves coarse, blunt, deltoid, slightly exerted; up to 7 lines long and 7 lines in diameter.



**Habitat.**—Coomer Plains, 8 to 10 miles south of Brisbane (F. M. Bailey), and as far south as Copmanhurst and Grafton District, N.S.W.

**REMARKS.**—This species was founded on mixed material, as shown by the original now in the National Herbarium, Melbourne. The description of the leaves and buds in Mueller's *Eucalyptographia* and also his *Fragmenta*, do not apply to the above description of these organs, but rather to those from the trees having fruits similar to those figured by Mueller (*loc. cit.*).

**ESSENTIAL OIL.**—Leaves and terminal branchlets for distillation were obtained from Copmanhurst, New South Wales, in April, 1920. The crude oil was of a dark amber colour, and had a turpentine-like odour. The yield of oil was 0.82 per cent. It was quite mobile, and consisted principally of dextro-rotatory pinene and lævo-rotatory aromadendrene. It also contained a very little cineol, some alcoholic bodies, together with a small amount of volatile aldehydes. Neither phellandrene nor crystallised eudesmol was detected.



We were the more anxious to obtain the oil of this species in order to determine its constituents, because those previously stated to occur appeared contrary to what might be expected from a species belonging to the group in which *E. Baileyana* is placed botanically. We failed to find either citral or phellandrene, so that evidently the previous statements refer to the oil of a species other than this.

The crude oil had specific gravity at  $15^{\circ}$  C. = 0.8928; optical rotation  $a_D + 14^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4767, and was only just soluble in 10 volumes 80 per cent. alcohol. The saponification number for the esters and free acid was 2.5 both by the hot and cold method. After acetylation it was 31.7 by boiling, and 11.2 in the cold with two hours' contact.

On rectification less than 1 per cent. distilled below  $157^{\circ}$  C. (corr.). Between  $157-161^{\circ}$ , 5 per cent. distilled; between  $161-166^{\circ}$ , 30 per cent.;  $166-174^{\circ}$ , 16 per cent.;  $174-193^{\circ}$ , 16 per cent.;  $193-254^{\circ}$ , 5 per cent., and  $254-268^{\circ}$ , 26 per cent. These fractions gave the following results:—

|                |                                                                                                                 |
|----------------|-----------------------------------------------------------------------------------------------------------------|
| First fraction | sp. gr. at $15^{\circ}$ C. = 0.8631; rotation $a_D + 27.1^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4651. |
| Second         | „ „ = 0.8682; rotation $a_D + 25.3$ ; refractive index at $20^{\circ}$ = 1.4660.                                |
| Third          | „ „ = 0.8719; rotation $a_D + 21.6^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4672.                        |
| Fourth         | „ „ = 0.8780; rotation $a_D + 16.3^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4686.                        |
| Fifth          | „ „ = 0.8855; rotation $a_D + 3.5^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4715.                         |
| Sixth          | „ „ = 0.9316; rotation $a_D - 1.2^{\circ}$ ; refractive index at $20^{\circ}$ = 1.4988.                         |

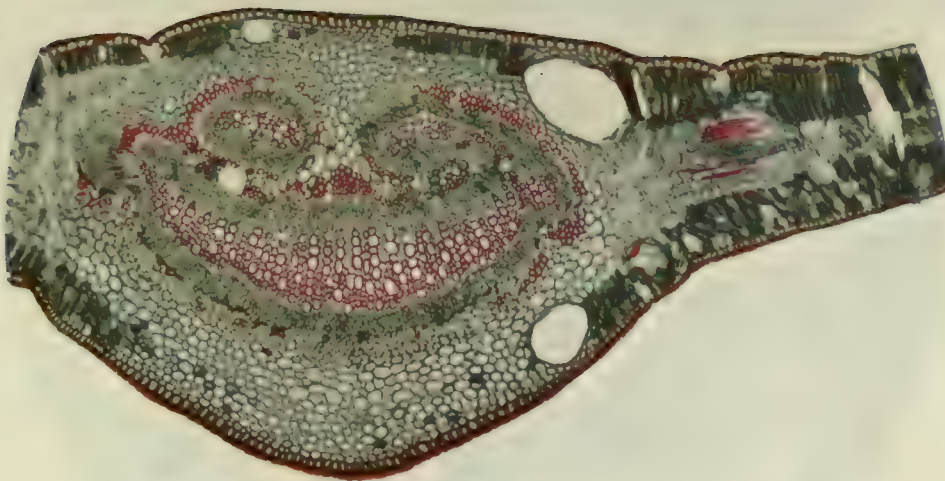
The sixth fraction contained a small quantity of a sesquiterpene alcohol, as the saponification number after acetylation was 45.

The cineol was determined by the resorcinol method in the portion distilling below  $190^{\circ}$  C.; when calculated for the crude oil the result was 7 per cent.

The pinene was prepared in a pure condition, the cineol being first removed by agitating with 50 per cent. resorcinol. The terpene boiled at  $155-156^{\circ}$  C.; had optical rotation  $a_D + 30.1^{\circ}$ ; specific gravity at  $15^{\circ}$  = 0.8633, and refractive index at  $20^{\circ}$  = 1.4661. The nitrosochloride was prepared, and this melted at  $104^{\circ}$  C.

The sesquiterpene was also prepared as pure as possible by refractionation under reduced pressure over sodium. This boiled at  $123-125^{\circ}$  at 10 millimetres pressure; had specific gravity at  $15^{\circ}$  = 0.924; optical rotation  $a_D - 3.7^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4964, and gave the colour reactions characteristic for this sesquiterpene. This species falls in our Group I.





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A cross section through the exceptionally stout mid-rib characteristic of this species, and portions of the blade on either side of it. On the right of the bundle top and bottom are two larger oil glands. The palisade parenchyma is more developed towards the upper surface, and the spongy mesophyll occupies about a third of the area of the section. The supporting tissue is particularly well developed around the bundle, which is bicollateral, backed by a rather broken ring of thick walled woody fibres fresh. The compact rings of the phloem (green) are seen to contrast with the larger cells of the supporting tissue.  $\times 75$ .

EUCALYPTUS BAILEYANA. F.V.M.

no vult  
absculit

## 178. *Eucalyptus obtusiflora*.

(DC., Prod., iii, p. 220; and Mem. Myrt., t. 10.)

**Systematic.**—A stunted tree, with either a smooth or roughish bark. Leaves lanceolate, rarely falcate, shortly acuminate, usually about 3 inches long and under 1 inch wide, petiole flattened, often shining; venation distinctly marked, lateral veins spreading, intramarginal vein removed from the edge. Peduncles axillary, flattened, about 1 inch long, bearing four to eight flowers. Buds sometimes 6 lines long and 2 lines broad, and constricted below the operculum; calyx 4 lines in diameter; operculum depressed, but sometimes almost conical, or shortly acuminate.

**Fruit.**—Shortly pedicellate, ovoid-truncate, contracted at the rim, which is thin and countersunk; valves inserted; about 9 lines long and 5 lines broad.

*They have a strong resemblance to E. stricta, E. apiculata, or E. trachyphloia.*



**Habitat.**—This is a small stunted shrub found mostly on the Hawkesbury sandstone, New South Wales.

**REMARKS.**—The leaves are thick, straight, and rigid, and might serve as a fodder, as their yield of oil is nil, as far as our experience goes. Leaves were obtained from La Perouse, N.S.W., 7th June, 1898. Although 280 lb. of leaves and branchlets were put through the still, not a drop of oil was obtained—not even sufficient to form a film upon the surface of the water in the receiver. We have obtained but very little oil from several species, but this is the only one from which we have obtained none. (See tabulated list for percentages of oil obtained.)





PART III.

TECHNOLOGICAL AND  
CHEMICAL.







## Tabulated Results obtained with the Crude Oils, at time of distillation, together with their Chief Constituents.

COMPLETE data in reference to the oils of individual species are not given here, and fuller information concerning any particular oil will be found recorded under that species, to which further reference may be made. Where more than one result is given, the figures represent the highest and lowest and refer alone to our own investigations.

The differences shown with a particular oil are largely controlled by a predominance of a certain constituent characteristic of the species, and the time taken for the original distillation is also a contributing factor in varying the amount of high-boiling constituents. In the list of principal constituents recorded for each species, only the more pronounced are included, but others than those listed often occur in small quantities, and as these are of a general character they are not included in the list.

The specific gravities were taken at room temperature and corrected for 15° C., the correction for each degree being 0.00075. The refractive indices are the readings for a Zeiss Abbé refractometer with heatable prisms, and corrected for 20° C., the correction used being 0.00047 for each degree. The saponification number with many of the oils is large; this number is the sum of the esters and free acid values, although the free acid with most species is very small indeed. The solubilities in alcohol are, to a certain extent, an indication of the amount of constituents containing oxygen, and the determination is one of considerable value. The alcohol was standardised for absolute alcohol by weight, as a greater uniformity in strength could thus be secured. The 70 per cent. alcohol had specific gravity 0.872 and the 80 per cent. 0.8483, both at 15.5° C. If the oil was not soluble in 10 volumes 80 per cent. alcohol, it is classed as insoluble.

Volatile aldehydes occur in all crude Eucalyptus oils; where mentioned they were more pronounced than usual.

The phenols, tasmanol and australol, occur in all crude Eucalyptus oils, and for that reason are not tabulated; the amount present is usually very small.

Eudesmol occurs in both the liquid and crystallised conditions; where the word eudesmol alone is given it means the crystalline form.

Cineol is recorded in percentages for the original oils when first distilled, and also in an adjoining column for the identical samples after these had been stored away from the light and air for about 20 years. The analyses of the oils at this later period are recorded under the species in this work. With several of the oils increases in cineol were noticeable, and as the results in both cases were obtained by the phosphoric acid method they are comparable. With the majority of species, however, little or no alteration in cineol content had taken place.

The letters placed with the figures in the cineol columns indicate that the determinations were made by (R) the resorcinol method; (T) qualitatively determined, and (P) by the phosphoric acid method. In cases where letters are omitted, the determinations were carried out with phosphoric acid.

The yields of oil will be found recorded in a separate table. Articles dealing with the chief constituents will also be found in this work.

|                                         | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $a_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                      | Principal Constituents.                                                            |
|-----------------------------------------|----------------------------------------|------------------------------------|----------------------------|--------------------------|----------------------------|------------------------|---------------------------------------------|------------------------------------------------------------------------------------|
|                                         | In original oils when first distilled. | In same oils after about 20 years. |                            |                          |                            |                        |                                             |                                                                                    |
| <i>E. acaciæformis</i>                  | ...                                    | ...                                | 0.8864                     | +35.7°                   | 1.4713                     | 17.4                   | Insoluble                                   | Pinene, sesquiterpene, geranyl-acetate.                                            |
| <i>E. accedens</i>                      | ...                                    | ...                                | 0.9084                     | +13.4°                   | 1.4691                     | 4.6                    | 9 vols. 70 per cent.                        | Pinene, cineol, eudesmol, sesquiterpene.                                           |
| <i>E. acervula</i>                      | ...                                    | ...                                | 0.8957 to 0.930.           | -1.1° to -1.4°           | 1.4724 to 1.4870.          | 32.8 to 40.7.          | 1 vol. 80 per cent.                         | Pinene, phellandrene, cineol, geraniol, geranyl-acetate, paraffins, sesquiterpene. |
| <i>E. acmenioides</i>                   | ...                                    | ...                                | 0.9252                     | Not taken                | 1.5008                     | 8.6                    | 1 vol. 80 per cent.                         | Pinene, phellandrene, sesquiterpene.                                               |
| <i>E. affinis</i>                       | ...                                    | ...                                | 0.9259                     | +5.6°                    | 1.4864                     | 4.7                    | 1 vol. 80 per cent.                         | Pinene, cineol, sesquiterpene, aromadendral.                                       |
| <i>E. aggregata</i>                     | ...                                    | ...                                | 0.9474 to 0.956.           | +1.2°                    | 1.4977 to 1.5005.          | 112.2 to 119.5.        | Insoluble                                   | Pinene, amyl-alcohol, amyl-eudesmate, amyl-phenylacetate.                          |
| <i>E. albens</i>                        | ...                                    | ...                                | 0.9044                     | -6.5°                    | 1.4679                     | 8.5                    | 1 vol. 80 per cent.                         | Pinene, cymene, cineol, aromadendral.                                              |
| <i>E. alpina</i>                        | ...                                    | ...                                | 0.8973                     | -2.8°                    | 1.4756                     | 2.6                    | Insoluble                                   | Pinene, cineol, paraffin, sesquiterpene, polyterpenes.                             |
| <i>E. amygdalina</i>                    | ...                                    | ...                                | 0.8668 to 0.8848.          | -59.1° to -75.1°         | 1.4752 to 1.4781.          | 2.9 to 3.2.            | 7 vols. 70 per cent. to 1 vol. 80 per cent. | Phellandrene, cineol, piperitone, sesquiterpene.                                   |
| <i>E. amygdalina</i> var. <i>nitida</i> | ...                                    | ...                                | 0.8625 to 0.8665.          | -45.74° to -57.8°        | 1.4805 to 1.4833.          | 4.5 to 6.2.            | insoluble                                   | Phellandrene, eudesmol, cineol, geraniol, piperitone.                              |
| <i>E. Andreasi</i>                      | ...                                    | ...                                | 0.8646                     | -41.5°                   | 1.4831                     | 4.3                    | "                                           | Phellandrene, piperitone, free alcohols, sesquiterpene.                            |
| <i>E. angophoroides</i>                 | ...                                    | ...                                | 0.9047                     | -11.5°                   | 1.4824                     | 7.3                    | 1 vol. 80 per cent.                         | Phellandrene, cineol, pinene, sesquiterpene.                                       |
| <i>E. apiculata</i>                     | ...                                    | ...                                | 0.9056 to 0.9112.          | -7.8° to -8.4°           | 1.4877                     | 8.7 to 10.05.          | 1 vol. 80 per cent.                         | Pinene, piperitone, cineol, alcoholic bodies, esters, sesquiterpene.               |
| <i>E. Australiana</i> —<br>(Whole oil)  | ...                                    | ...                                | 0.9157                     | +2.8°                    | 1.4644                     | 8.9                    | 1 1/4 vols. 70 per cent.                    | Cineol, terpineol, geraniol, pinene, piperitone, citral, paraffin.                 |
| (1st hour oil) mean results             | ...                                    | ...                                | 0.9196                     | +0.9°                    | 1.4627                     | ...                    | 1.1 vol. 70 per cent.                       |                                                                                    |
| <i>E. Baenerleni</i>                    | ...                                    | ...                                | 0.8895                     | +4.05°                   | 1.4784                     | 9.98                   | 4 vols. 80 per cent.                        | Cineol, pinene, eudesmol, sesquiterpene.                                           |



|                           | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $\alpha_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                       | Principal Constituents.                                                 |
|---------------------------|----------------------------------------|------------------------------------|----------------------------|-------------------------------|----------------------------|------------------------|----------------------------------------------|-------------------------------------------------------------------------|
|                           | In original oils when first distilled. | In same oils after about 20 years. |                            |                               |                            |                        |                                              |                                                                         |
| <i>E. Bancroftii</i> ...  | ...                                    | ...                                | 0.8982                     | -14.4°                        | 1.4721                     | 12.9                   | 1 vol. 80 per cent.                          | Pinene, phellandrene, cineol, alcoholic bodies.                         |
| <i>E. Behriana</i> ...    | ...                                    | 53                                 | 0.9237                     | +3.7°                         | 1.4708                     | 11.1                   | 1½ vols. 70 per cent.                        | Cineol, pinene, liquid eudesmol, sesquiterpene.                         |
| <i>E. bicolor</i> ...     | ...                                    | 62                                 | 0.9155                     | +5.5°                         | 1.4675                     | 8.4                    | 1½ vols. 70 per cent.                        | Cineol, pinene.                                                         |
| <i>E. Blaslandi</i> ...   | ...                                    | ...                                | 0.8881                     | +11.0°                        | 1.4653                     | 4.8                    | 6 vols. 80 per cent.                         | Pinene, cineol, sesquiterpene.                                          |
| <i>E. Bosistoana</i> ...  | ...                                    | 58                                 | 0.9078                     | +9.26°                        | 1.4675                     | 3.2                    | 5 vols. 70 per cent.                         | Cineol, pinene, terpineol, sesquiterpene.                               |
| <i>E. botryoides</i> ...  | ...                                    | ...                                | 0.8774 to 0.8778.          | +23.75° (1st frac.).          | 1.4730                     | 15.2 to 21.4           | 7 vols. 80 per cent. to 9 vols. 80 per cent. | Pinene, sesquiterpene, esters.                                          |
| <i>E. Bridgesiana</i> ... | ...                                    | 79                                 | 0.9120 to 0.9246.          | +1.8° to +3.35°               | 1.4655 to 1.4672.          | 6.2 to 8.7             | 1½ vols. 70 per cent.                        | Cineol, pinene, sesquiterpene.                                          |
| <i>E. cærulea</i> ...     | ...                                    | 20                                 | 0.9158                     | +12.7°                        | 1.4827                     | 6.4                    | 1 vol. 80 per cent.                          | Pinene, phellandrene, cineol, liquid eudesmol, geraniol, sesquiterpene. |
| <i>E. calophylla</i> ...  | ...                                    | ...                                | 0.8756                     | +22.9°                        | 1.4731                     | 10.5                   | Insoluble                                    | Pinene, cymene, sesquiterpene, esters.                                  |
| <i>E. calycogona</i> ...  | ...                                    | 50                                 | 0.9152                     | +7.6°                         | 1.4659                     | 7.3                    | 5 vols. 70 per cent.                         | Pinene, cineol, alcoholic bodies, sesquiterpene.                        |
| <i>E. campamilata</i> ... | ...                                    | 5 T.                               | 0.8804                     | -25.8°                        | 1.4847                     | 7.6                    | Insoluble                                    | Phellandrene, cineol, eudesmol, piperitone, sesquiterpene.              |
| <i>E. camphora</i> ...    | ...                                    | 50                                 | 0.9071 to 0.9167.          | +1.3°                         | 1.4676                     | 4.4                    | 1½ vols. 70 per cent.                        | Cineol, pinene, eudesmol, sesquiterpene, volatile aldehydes.            |
| <i>E. capitellata</i> ... | ...                                    | 25                                 | 0.9175                     | +4.4°                         | 1.4771                     | 4.3                    | 1 vol. 80 per cent.                          | Cineol, pinene, phellandrene, sesquiterpene.                            |
| <i>E. carnea</i> ...      | ...                                    | 11 R.                              | 0.8901 to 0.8963.          | +37.2° to +39.0°              | 1.4681                     | 35.5                   | 7 vols. 80 per cent.                         | Pinene, cineol, terpinyl-acetate, sesquiterpene.                        |
| <i>E. cinerea</i> ...     | ...                                    | 60                                 | 0.9113 to 0.9225.          | +2.5° to +4.1°                | 1.4649                     | 14.4 to 24.0           | 1½ vols. 70 per cent.                        | Cineol, pinene, esters, volatile aldehydes, sesquiterpene.              |
| <i>E. citriodora</i> ...  | ...                                    | ...                                | 0.8657 to 0.8697.          | -1.0° to +1.7°                | 1.4515 to 1.4596.          | 7                      | 1½ vols. 70 per cent.                        | Citronellal, esters, free alcohol/s.                                    |
| <i>E. cneorifolia</i> ... | ...                                    | 62                                 | 0.9229                     | -3.3°                         | 1.4664                     | 7.4                    | 1½ vols. 70 per cent.                        | Cineol, pinene, aromadendral, alcoholic bodies.                         |



|                            | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $\alpha_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol. | Principal Constituents.                                                            |
|----------------------------|----------------------------------------|------------------------------------|----------------------------|-------------------------------|----------------------------|------------------------|------------------------|------------------------------------------------------------------------------------|
|                            | In original oils when first distilled. | In same oils after about 20 years. |                            |                               |                            |                        |                        |                                                                                    |
| <i>E. coccifera</i> ...    | 5T.                                    | ...                                | 0.8810                     | -35.8°                        | 1.4849                     | 4.9                    | Insoluble              | Phellandrene, cineol, eudesmol, piperitone, sesquiterpene.                         |
| <i>E. conica</i> ...       | 35                                     | 48                                 | 0.9057                     | +5.24°                        | 1.4676                     | 6.26                   | 6 vols. 70 per cent.   | Cineol, pinene, sesquiterpene, volatile aldehydes.                                 |
| <i>E. Consideriana</i> ... | 40                                     | ...                                | 0.9207                     | +2.9°                         | 1.4737                     | 3.7                    | 2 vols. 70 per cent.   | Cineol, phellandrene (traces), pinene, liquid eudesmol, paraffin, terpineol.       |
| <i>E. cordata</i> ...      | 55                                     | 65                                 | 0.9138                     | +8.5°                         | 1.4638                     | 14.85                  | 1½ vols. 70 per cent.  | Cineol, pinene, esters, volatile aldehydes, sesquiterpene.                         |
| <i>E. coriacea</i> ...     | 5T.                                    | 6R.                                | 0.8947 to 0.8983.          | -27.0° to -29.3°              | 1.4845 to 1.4890.          | 3.7 to 4.6.            | 1 vol. 80 per cent.    | Phellandrene, pinene, piperitone, eudesmol, cineol, sesquiterpene.                 |
| <i>E. cornuta</i> ...      | 31                                     | ...                                | 0.9043                     | +10.1°                        | 1.4601                     | 25.4                   | 2 vols. 70 per cent.   | Pinene, cineol, amyl-alcohol, esters, alcohols, sesquiterpene, volatile aldehydes. |
| <i>E. corymbosa</i> ...    | Traces                                 | ...                                | 0.883                      | -8.4°                         | 1.4838                     | 3.8                    | Insoluble              | Pinene, aromadendral, sesquiterpene, cineol.                                       |
| <i>E. corynocalyx</i> ...  | 20R.                                   | ...                                | 0.8945                     | +8.1°                         | 1.4779                     | 7.7                    | 4 vols. 80 per cent.   | Pinene, cineol, sesquiterpene.                                                     |
| <i>E. cosmophylla</i> ...  | 43                                     | ...                                | 0.9108                     | -3.2°                         | 1.4659                     | 5.6                    | 7 vols. 70 per cent.   | Cineol, pinene, aromadendral, sesquiterpene.                                       |
| <i>E. costata</i> ...      | 57                                     | ...                                | 0.9216                     | +4.8°                         | 1.4657                     | 4.5                    | 1½ vols. 70 per cent.  | Cineol, pinene, alcoholic bodies, sesquiterpene.                                   |
| <i>E. crebra</i> ...       | 22                                     | ...                                | 0.8986                     | -10.8°                        | 1.4787                     | 6.2                    | Insoluble              | Phellandrene, pinene, cineol, sesquiterpene.                                       |
| <i>E. Dalrympleana</i> ... | 50                                     | ...                                | 0.9133 to 0.9145.          | +4.6° to +6.7°.               | 1.4639 to 1.4645.          | 7.8 to 8.5.            | 2 vols. 70 per cent.   | Cineol, pinene, esters, sesquiterpene.                                             |
| <i>E. Dawsoni</i> ...      | Traces                                 | 5R.                                | 0.9418                     | *-23.5°                       | 1.5077                     | 13.3                   | 2 vols. 80 per cent.   | Phellandrene, cineol, esters, sesquiterpene, polyterpenes.                         |
| <i>E. dealbata</i> ...     | 52                                     | 73                                 | 0.9261                     | +3.8°                         | 1.4648                     | 2.1                    | 1½ vols. 70 per cent.  | Cineol, pinene, sesquiterpene, liquid eudesmol.                                    |
| <i>E. Deanei</i> ...       | 8T.                                    | ...                                | 0.9216.                    | -3.2°                         | 1.4896                     | 21.4                   | 2 vols. 80 per cent.   | Pinene, cineol, cymene, aromadendral, esters, sesquiterpene.                       |
| <i>E. Delegatensis</i> ... | Traces                                 | ...                                | 0.8596 to 0.8676.          | -47.4° to -58.6°.             | 1.4812 to 1.4863.          | 3.1 to 3.5.            | Insoluble              | Phellandrene, piperitone.                                                          |
| <i>E. dextropinea</i> ...  | 5T.                                    | 6R.                                | 0.8758 to 0.8778.          | *+32.46° to +32.83°           | 1.4684                     | 22.9                   | Insoluble              | Pinene, esters, cineol, sesquiterpene.                                             |

\* 1st Fraction.

|                        | Cineol Percentages.                    |                                    | Specific Gravity at 15° C.                           | Optical Rotation $a_D$ .                                         | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                                                                 | Principal Constituents.                                                     |
|------------------------|----------------------------------------|------------------------------------|------------------------------------------------------|------------------------------------------------------------------|----------------------------|------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                        | In original oils when first distilled. | In same oils after about 20 years. |                                                      |                                                                  |                            |                        |                                                                                        |                                                                             |
| <i>E. diversicolor</i> | ...                                    | ...                                | 0.8948 to 0.9145.                                    | +20.5° to +30.1°.                                                | 1.4671 to 1.4748.          | 41 to 53.2.            | 1 vol. 80 per cent. to 4 vols. 80 per cent.                                            | Pinene, terpineol, geraniol and their esters, butylbutyrate, sesquiterpene. |
| <i>E. dives</i>        | ...                                    | ...                                | 0.8713 to 0.9020, according to time of distillation. | -55.4° to -64.3°.                                                | 1.4798 to 1.4811.          | 2.9                    | 1 vol. 80 per cent. to insoluble; solubility governed by amount of piperitone present. | Phellandrene, pinene, piperitone, cineol, alcoholic bodies.                 |
| <i>E. dumosa</i>       | ...                                    | ...                                | 0.9016 to 0.9151.                                    | +2.2° to +16.4°.                                                 | 1.4667 to 1.4703.          | 2.9 to 3.7.            | 1½ vols. 70 per cent. to 1 vol. 80 per cent.                                           | Cineol, pinene, aromadendral.                                               |
| <i>E. elaeophora</i>   | ...                                    | 66                                 | 0.9191 to 0.9266.                                    | +3.1° to +5.7°.                                                  | 1.4663                     | 8.7                    | 1¼ vols. 70 per cent.                                                                  | Cineol, pinene, eudesmol, aromadendral, esters.                             |
| <i>E. eugenoides</i>   | ...                                    | 58                                 | 0.9122 to 0.9132.                                    | +3.4° to +4.8°.                                                  | 1.4694                     | 6.9                    | 6½ vols. 70 per cent., solubility increases on keeping.                                | Cineol, pinene, sesquiterpene.                                              |
| <i>E. eximia</i>       | ...                                    | ...                                | 0.8998                                               | +28.8°                                                           | 1.4832                     | 4.5                    | Insoluble ...                                                                          | Pinene, sesquiterpene, liquid eudesmol, geraniol.                           |
| <i>E. exserta</i>      | ...                                    | ...                                | 0.8977                                               | +12.2°                                                           | 1.4729                     | 4.7                    | 5 vols. 80 per cent.                                                                   | Cineol, pinene, aromadendral, sesquiterpene, volatile aldehydes.            |
| <i>E. fasciculosa</i>  | ...                                    | ...                                | 0.9041                                               | +6.3°                                                            | 1.4789                     | 22.1                   | 10 vols. 80 per cent.                                                                  | Cineol, pinene, esters, sesquiterpene.                                      |
| <i>E. fastigata</i>    | ...                                    | 10R.                               | 0.8925 to 0.9001.                                    | +2.8° to -9.5° (1st fract.) depending on amount of phellandrene. | 1.4816                     | 12.4 to 14.9.          | 5 vols. 80 per cent. to insoluble.                                                     | Pinene, phellandrene, eudesmol, cineol.                                     |

|                                                    | Cineol Percentages.                    |                                    | Specific Gravity at 15° C.  | Optical Rotation $\alpha_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                                               | Principal Constituents.                                                                               |
|----------------------------------------------------|----------------------------------------|------------------------------------|-----------------------------|-------------------------------|----------------------------|------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
|                                                    | In original oils when first distilled. | In same oils after about 20 years. |                             |                               |                            |                        |                                                                      |                                                                                                       |
| <i>E. Fletcheri</i> ...                            | ...                                    | 10T.                               | 0.8805 to 0.8950.           | —12.5°                        | 1.4824                     | 3.4                    | 2 vols. 80 per cent. to insoluble.                                   | Phellandrene, pinene, aromadendral, sesquiterpene.                                                    |
| <i>E. fraxinoides</i> ...                          | ...                                    | 10T.                               | 0.8687                      | —27.5°                        | 1.4851                     | 3.7                    | Insoluble ...                                                        | Phellandrene, pinene, cineol, piperitone, eudesmol, sesquiterpene, citral.                            |
| <i>E. globulus</i> ...                             | ...                                    | 57                                 | 0.913                       | +8.4°                         | 1.4663                     | 2.1                    | 1½ vols. 70 per cent.                                                | Cineol, pinene, eudesmol, sesquiterpene, volatile aldehydes.                                          |
| <i>E. gomphocephala</i><br><i>E. gomocalyx</i> ... | ...                                    | Nil.<br>56                         | 0.8759<br>0.9117 to 0.9125. | Not taken<br>+4.35° to +7.2°. | 1.4758<br>1.4689           | 25.7<br>13.3           | Insoluble ...<br>1½ vols. 70 per cent.                               | Phellandrene, pinene, esters.<br>Cineol, pinene, eudesmol, sesquiterpene, esters, volatile aldehydes. |
| <i>E. gracilis</i> ...                             | ...                                    | 19                                 | 0.9098                      | +1.35°                        | 1.4714                     | 6.2                    | 1 vol. 80 per cent.                                                  | Cineol, pinene, cymene, aromadendral, volatile aldehydes.                                             |
| <i>E. Gullicki</i> ...                             | ...                                    | 46                                 | 0.9285                      | +6.7°                         | 1.4717                     | 4.6                    | 1½ vols. 70 per cent.                                                | Pinene, cineol, eudesmol, geraniol.                                                                   |
| <i>E. Gunnii</i> ...                               | ...                                    | 26                                 | 0.8984 to 0.9014.           | —4.3° to +4.7°.               | 1.4743 to 1.4799.          | 4.4 to 6.7.            | 4 vols. 80 per cent. to 8 vols. 80 per cent.                         | Pinene, phellandrene, cineol, liquid eudesmol, sesquiterpene.                                         |
| <i>E. haemastoma</i> ...                           | ...                                    | 9R.                                | 0.9065 to 0.9195.           | —5.5°                         | 1.4902 to 1.4955.          | 4.4 to 5.1.            | 1 vol. 80 per cent. to insoluble, due to amount of eudesmol present. | Phellandrene, cineol, eudesmol, geraniol, sesquiterpene.                                              |
| <i>E. hemilampira</i> ...                          | ...                                    | 35                                 | 0.9282                      | +7.09°                        | 1.4678                     | 24.4                   | 1½ vols. 70 per cent.                                                | Cineol, pinene, esters, alcoholic bodies, volatile aldehydes, sesquiterpene.                          |
| <i>E. hemiphloia</i> ...                           | ...                                    | 18                                 | 0.9117                      | —6.85°                        | 1.4853                     | 5.8                    | 2 vols. 70 per cent.                                                 | Pinene, cineol, aromadendral, cymene, alcoholic bodies, sesquiterpene.                                |
| <i>E. intermedia</i> ...                           | ...                                    | Traces ..                          | 0.8829 to 0.8881.           | +9.9° to +12.2°.              | 1.4821                     | 2.5 to 3.8.            | Insoluble ...                                                        | Pinene, sesquiterpene, aromadendral.                                                                  |
| <i>E. intertexta</i> ...                           | ...                                    | 35                                 | 0.9078                      | +9.71° to +10.25°             | 1.4691                     | 4.9 to 5.4.            | 2 vols. 70 per cent.                                                 | Cineol, pinene, sesquiterpene.                                                                        |



|                                                | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $a_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                         | Principal Constituents.                                             |
|------------------------------------------------|----------------------------------------|------------------------------------|----------------------------|--------------------------|----------------------------|------------------------|------------------------------------------------|---------------------------------------------------------------------|
|                                                | In original oils when first distilled. | In same oils after about 20 years. |                            |                          |                            |                        |                                                |                                                                     |
| <i>E. Irbyi</i>                                | 15P.                                   | ...                                | 0.9021                     | -1.7°                    | 1.4829                     | 8.5                    | 4 vols. 80 per cent.                           | Pinene, phellandrene, cineol, sesquiterpene.                        |
| <i>E. lactea</i>                               | 10T.                                   | 22R.                               | 0.8752 to 0.8826.          | Inactive                 | 1.4845                     | 8.56 to 11.53.         | 2 vols. 80 per cent. to 5 vols. 80 per cent.   | Pinene, cymene, cineol, eudesmol, sesquiterpene.                    |
| <i>E. levopinea</i>                            | 10T.                                   | 13R.                               | 0.8755 to 0.8875.          | -30.7° to -37.8°.        | 1.4686 to 1.4704.          | 7 to 11                | 10 vols. 80 per cent.                          | Pinene, cineol, sesquiterpene.                                      |
| <i>E. Laseroni</i>                             | 5T.                                    | ...                                | 0.9095                     | -8.1°                    | 1.4790                     | 13.4                   | 6 vols. 80 per cent.                           | Pinene, cineol, phellandrene, esters, sesquiterpene.                |
| <i>E. Lehmanni</i>                             | 20                                     | ...                                | 0.8964                     | +17.5°                   | 1.4653                     | 6.7                    | 1 vol. 80 per cent.                            | Pinene, cineol, sesquiterpene, volatile aldehydes.                  |
| <i>E. leucoxylon</i>                           | 27                                     | ...                                | 0.8987                     | +9.2°                    | 1.4711                     | 3.8                    | 1 vol. 80 per cent.                            | Pinene, limonene, cineol, sesquiterpene.                            |
| <i>E. ligustrina</i>                           | 5R.                                    | ...                                | 0.9499                     | +22.4°                   | 1.4974                     | 9.0                    | 1 vol. 80 per cent.                            | Eudesmol, pinene, cineol, geranyl-acetate, geraniol, sesquiterpene. |
| <i>E. linearis</i>                             | 46                                     | ...                                | 0.9036 to 0.9096.          | -9.9° to -23.1°.         | 1.4677 to 1.4734.          | 5.8                    | 6 vols. 70 per cent. to 8 vols. 70 per cent.   | Phellandrene, cineol, liquid eudesmol, sesquiterpene.               |
| <i>E. longicornis</i>                          | 56                                     | ...                                | 0.9203                     | +5.0°                    | 1.4670                     | 10.8                   | 1½ vols. 70 per cent.                          | Pinene, cineol, esters, alcoholic bodies, sesquiterpene.            |
| <i>E. longifolia</i>                           | 45                                     | 61                                 | 0.9226                     | +2.86°                   | 1.4681                     | 3.6                    | 1½ vols. 70 per cent.                          | Cineol, pinene, sesquiterpene.                                      |
| <i>E. Luehmanniana</i>                         | 10T.                                   | ...                                | 0.879                      | -27.5°                   | 1.4880                     | 2.3                    | Insoluble                                      | Phellandrene, pinene, cineol, piperitone, eudesmol.                 |
| <i>E. Macarthurii</i><br>(including bark oil). | Nil.                                   | ...                                | 0.9214 to 0.9245.          | +1.2° to +3.6°.          | 1.4706 to 1.4718.          | 173.4 to 224.0.        | 1½ vols. 70 per cent. to 1½ vols. 70 per cent. | Geranyl-acetate, free geraniol, pinene, eudesmol.                   |
| <i>E. macrorhyncha</i>                         | 30                                     | ...                                | 0.929                      | -1.0° (1st fract.)       | 1.4745                     | 8.4                    | 1½ vols. 70 per cent.                          | Pinene, phellandrene, cineol, eudesmol, sesquiterpene.              |
| <i>E. maculata</i>                             | 20                                     | 21                                 | 0.8959 to 0.9201.          | +5.1° to +7.7°.          | 1.4804                     | 6.5 to 9.5.            | 1 vol. 80 per cent. to 4 vols. 80 per cent.    | Pinene, cineol, sesquiterpene.                                      |

|                            | Cineol Percentages.                    |                                    | Specific Gravity at 15° C.  | Optical Rotation $a_D$                                    | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                                                   | Principal Constituents.                                        |
|----------------------------|----------------------------------------|------------------------------------|-----------------------------|-----------------------------------------------------------|----------------------------|------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------|
|                            | In original oils when first distilled. | In same oils after about 20 years. |                             |                                                           |                            |                        |                                                                          |                                                                |
| <i>E. maculosa</i> ...     | ...                                    | 55                                 | 0.9158 to 0.9229.<br>0.9247 | +2.3° to +3.35°.<br>+5.8°                                 | 1.4684<br>1.4679           | 8.7 to 21.3.<br>21.8°  | 1 $\frac{3}{4}$ vols. 70 per cent.<br>1 $\frac{1}{2}$ vols. 70 per cent. | Cineol, pinene, liquid eudesmol, esters, sesquiterpene.        |
| <i>E. Maideni</i> ...      | ...                                    | 62                                 | ...                         | ...                                                       | ...                        | ...                    | ...                                                                      | Cineol, pinene, esters, sesquiterpene.                         |
| <i>E. marginata</i> ...    | ...                                    | ...                                | 0.8889 to 0.9117.           | -8.5° to -10.4°.                                          | 1.4889                     | 10.3 to 13.1.          | 1 vol. 80 per cent. to 5 vols. 80 per cent.                              | Pinene, cymene, cineol, aromadendral, sesquiterpene, esters.   |
| <i>E. Marsdeni</i> ...     | ...                                    | ...                                | 0.9469                      | +4.8°                                                     | 1.4989                     | 2.0                    | Insoluble ...                                                            | Sesquiterpene, pinene.                                         |
| <i>E. megacarpa</i> ...    | ...                                    | ...                                | 0.8852                      | -31.2°                                                    | 1.4719                     | 7.5                    | 10 vols. 80 per cent.                                                    | Pinene, limonene, terpinene, cineol, geranyl-acetate.          |
| <i>E. melanophloia</i> ... | ...                                    | 5T.                                | 0.8959                      | -23.5°                                                    | 1.4893                     | 11                     | Insoluble ...                                                            | Phellandrene, pinene, cymene, cineol, eudesmol, sesquiterpene. |
| <i>E. melliodora</i> ...   | ...                                    | 52                                 | 0.9042 to 0.9321.<br>0.895  | +5.0° to +6.5°.<br>+18.3°                                 | 1.4649<br>1.4690           | 7.2 to 21.96.<br>19.6  | 1 $\frac{1}{2}$ to 6 vols. 70 per cent.<br>1 vol. 80 per cent.           | Cineol, phellandrene, pinene, sesquiterpene, esters.           |
| <i>E. microcorys</i> ...   | ...                                    | 30P.                               | ...                         | ...                                                       | ...                        | ...                    | ...                                                                      | Cineol, pinene, esters, sesquiterpene.                         |
| <i>E. microtheca</i> ...   | ...                                    | 5T.                                | 0.8855                      | -27.2°                                                    | 1.4838                     | 4.3                    | Insoluble ...                                                            | Phellandrene, pinene, cineol, cymene, sesquiterpene.           |
| <i>E. Moorei</i> ...       | ...                                    | 56                                 | 0.9289                      | +6.12°                                                    | 1.4699                     | 6.1                    | 1 $\frac{1}{4}$ vols. 70 per cent.                                       | Cineol, pinene, eudesmol, paraffin, sesquiterpene.             |
| <i>E. Morrisii</i> ...     | ...                                    | 64                                 | 0.9097 to 0.9164.<br>0.9097 | +3.76° to +6.1°.<br>+10.4°                                | 1.4636<br>1.4647           | 8.1<br>15.3            | 1 $\frac{1}{2}$ vols. 70 per cent.<br>4 vols. 70 per cent.               | Cineol, pinene, sesquiterpene.                                 |
| <i>E. Muelleri</i> ...     | ...                                    | 57                                 | ...                         | ...                                                       | ...                        | ...                    | ...                                                                      | Cineol, pinene, esters, sesquiterpene.                         |
| <i>E. Nepeanensis</i> ...  | ...                                    | 68                                 | 0.9259                      | +1.1°                                                     | 1.4677                     | 3.6                    | 1 $\frac{1}{4}$ vols. 70 per cent.                                       | Cineol, pinene, sesquiterpene.                                 |
| <i>E. nigra</i> ...        | ...                                    | 11R.                               | 0.8744                      | -34.0°                                                    | 1.4706                     | 7.2                    | Insoluble ...                                                            | Pinene, cineol, sesquiterpene.                                 |
| <i>E. nova-anglica</i> ... | ...                                    | 6R.                                | 0.907 to 0.9301.            | +0.9° to -14.5°<br>(due to the amount of pinene present). | 1.4843 to 1.4932.          | 5.1 to 6.9.            | Insoluble ...                                                            | Pinene, sesquiterpene, cineol, alcohols.                       |

|                                                 | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $a_D$ | Refractive Index at 20° C.                           | Saponification Number. | Solubility in Alcohol.                       | Principal Constituents.                                    |
|-------------------------------------------------|----------------------------------------|------------------------------------|----------------------------|------------------------|------------------------------------------------------|------------------------|----------------------------------------------|------------------------------------------------------------|
|                                                 | In original oils when first distilled. | In same oils after about 20 years. |                            |                        |                                                      |                        |                                              |                                                            |
| <i>E. obliqua</i> ...                           | 8T.                                    | 15R.                               | 0.8836 to 0.8902.          | -24.2° to -28.8°.      | 1.4836 to 1.4877.                                    | 7.2 to 8.1.            | 1 vol. 80 per cent. to 4 vols. 80 per cent.  | Phellandrene, cineol, aromadendral, cymene.                |
| <i>E. occidentalis</i> ...                      | 36                                     | ...                                | 0.9135                     | +9.0°                  | 1.4717                                               | 2.5                    | 1 vol. 80 per cent.                          | Pinene, cineol, aromadendral, sesquiterpene.               |
| <i>E. odorata</i> ...                           | 63                                     | ...                                | 0.9193                     | -1.1°                  | 1.4639                                               | 8.5                    | 1 1/4 vols. 70 per cent.                     | Cineol, pinene, aromadendral, alcoholic bodies.            |
| <i>E. oleosa</i> ...                            | 52                                     | 62                                 | 0.925                      | -1.5°                  | 1.4689                                               | 4.9                    | 1 1/4 vols. 70 per cent.                     | Cineol, pinene, aromadendral, sesquiterpene.               |
| <i>E. oreades</i> ...                           | Traces                                 | ...                                | 0.8869                     | -22.7°                 | 1.4888                                               | 8.2                    | 1 vol. 80 per cent.                          | Phellandrene, pinene, eudesmol, piperitone, sesquiterpene. |
| <i>E. ovalifolia</i> ...                        | 5T.                                    | ...                                | 0.9058                     | -8.9°                  | 1.4864                                               | 6.2                    | 1 vol. 80 per cent.                          | Phellandrene, pinene, cineol, sesquiterpene.               |
| <i>E. ovalifolia</i> var. <i>lanceolata</i> ... | 45                                     | 56                                 | 0.9083                     | -4.26°                 | 1.4654                                               | 3.8                    | 2 vols. 70 per cent.                         | Pinene, phellandrene, cineol, sesquiterpene.               |
| <i>E. paludosa</i> ...                          | 23                                     | 26                                 | 0.9056                     | +10.0°                 | 1.4716                                               | 18.4                   | 1 vol. 80 per cent.                          | Pinene, cineol, geranyl-acetate, sesquiterpene.            |
| <i>E. paniculata</i> ...                        | 29                                     | ...                                | 0.901                      | +7.8°                  | 1.4744                                               | 7.11                   | 1 vol. 80 per cent.                          | Pinene, cineol, alcoholic bodies, sesquiterpene.           |
| <i>E. Parramattensis</i> ...                    | 75                                     | ...                                | 0.9223                     | +2.7°                  | 1.4629                                               | 4.6                    | 1 1/4 vols. 70 per cent.                     | Cineol, pinene, sesquiterpene, volatile aldehydes.         |
| <i>E. parvifolia</i> ...                        | 69                                     | ...                                | 0.9177                     | +3.6°                  | 1.4644                                               | 5.6                    | 1 1/4 vols. 70 per cent.                     | Cineol, pinene, liquid eudesmol, volatile aldehydes.       |
| <i>E. patentinervis</i> ...                     | Nil.                                   | ...                                | 0.8735                     | -15.2°                 | 1.4891                                               | 6.2                    | Insoluble                                    | Terpenes, limonene, citral, alcohols, sesquiterpene.       |
| <i>E. Perriniana</i> ...                        | 58                                     | ...                                | 0.9082 to 0.9119.          | +5.7° to +8.9°.        | 1.4612 to 1.4628.                                    | 12.3 to 52.5.          | 2 vols. 70 per cent. to 7 vols. 70 per cent. | Cineol, pinene, esters, volatile aldehydes, sesquiterpene. |
| <i>E. phlebophylla</i> ...                      | 9R.                                    | ...                                | 0.8766 to 0.9132.          | -19.1° to -32.5°.      | 1.4679 to 1.4836 (governed by the eudesmol present). | 3.2 to 4.0             | Insoluble                                    | Pinene, eudesmol, cineol.                                  |



|                        | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $\alpha_D$                            | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                           | Principal Constituents.                                                      |
|------------------------|----------------------------------------|------------------------------------|----------------------------|--------------------------------------------------------|----------------------------|------------------------|--------------------------------------------------|------------------------------------------------------------------------------|
|                        | In original oils when first distilled. | In same oils after about 20 years. |                            |                                                        |                            |                        |                                                  |                                                                              |
| <i>E. phellandra</i>   | ... 25 to 40                           | ...                                | 0.8948 to 0.9116.          | -7.1° to -22.2° (depending on amount of phellandrene). | 1.4700                     | 3.7                    | 1 1/4 vols. 70 per cent. to 3 vols. 70 per cent. | Cineol, phellandrene, pinene, eudesmol, terpineol, geraniol.                 |
| <i>E. pilularis</i>    | ... 8T.                                | 11R.                               | 0.885 to 0.903.            | -4.2° to +11.1° (1st fract. always laevo-rotatory).    | 1.4904                     | 5.9                    | 8 vols. 80 per cent. to insoluble.               | Phellandrene, pinene, cineol, sesquiterpene, liquid eudesmol.                |
| <i>E. piperita</i>     | ... 20P.                               | 22R.                               | 0.9111                     | -2.7°                                                  | 1.4781                     | 11.0                   | 1 vol. 80 per cent.                              | Phellandrene, pinene, cineol, piperitone, eudesmol, sesquiterpene.           |
| <i>E. planchoniana</i> | ... Nil.                               | ...                                | 0.9039                     | Not taken                                              | Not taken                  | 7.1                    | 1 vol. 80 per cent.                              | Phellandrene, sesquiterpene.                                                 |
| <i>E. platypus</i>     | ... 48                                 | ...                                | 0.9103                     | +10.2°                                                 | 1.4639                     | 15.2                   | 1 3/4 vols. 70 per cent.                         | Cineol, pinene, esters, alcoholic bodies, sesquiterpene, volatile aldehydes. |
| <i>E. polyanthemus</i> | ... 54                                 | 65                                 | 0.9281                     | +5.4°                                                  | 1.4679                     | 20.7                   | 1 1/4 vols. 70 per cent.                         | Cineol, pinene, esters, sesquiterpene.                                       |
| <i>E. polybractea</i>  | ... 75                                 | ...                                | 0.9143 to 0.9275.          | -1.9° to +1.8°.                                        | 1.4594 to 1.4679.          | 4.5                    | 1 vol. 70 per cent. to 1 1/2 vols. 70 per cent.  | Cineol, pinene, aromadendral, alcoholic bodies, sesquiterpene.               |
| <i>E. populifolia</i>  | ... 62                                 | 70                                 | 0.9207 to 0.923.           | +0.4° to +1.2°.                                        | 1.4652                     | 1.9                    | 1 1/4 vols. 70 per cent.                         | Cineol, pinene, sesquiterpene.                                               |
| <i>E. propinqua</i>    | ... 32                                 | 39                                 | 0.8980                     | +4.4°                                                  | 1.4731                     | 8.4                    | 8 vols. 70 per cent.                             | Pinene, cineol, aromadendral, sesquiterpene.                                 |
| <i>E. pulverulenta</i> | ... 60                                 | 74                                 | 0.9236                     | +2.12°                                                 | 1.4629                     | 18.4                   | 1 1/4 vols. 70 per cent.                         | Cineol, pinene, esters, sesquiterpene.                                       |
| <i>E. pumila</i>       | ... 74                                 | ...                                | 0.9237                     | +2.3°                                                  | 1.4683                     | 3.2                    | 1 1/4 vols. 70 per cent.                         | Cineol, pinene, aromadendral, sesquiterpene.                                 |
| <i>E. punctata</i>     | ... 55                                 | 55                                 | 0.9160                     | +0.85°                                                 | 1.4717                     | 18.8                   | 1 1/4 vols. 70 per cent.                         | Cineol, pinene, aromadendral, esters, sesquiterpene.                         |

|                                         | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $a_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                       | Principal Constituents.                                              |
|-----------------------------------------|----------------------------------------|------------------------------------|----------------------------|--------------------------|----------------------------|------------------------|----------------------------------------------|----------------------------------------------------------------------|
|                                         | In original oils when first distilled. | In same oils after about 20 years. |                            |                          |                            |                        |                                              |                                                                      |
| <i>E. punctata</i> var. <i>didyma</i>   | ...                                    | 12                                 | 0.9033 to 0.9070.          | -4.2° to -5.9°.          | 1.4811                     | 10.9 to 11.6.          | 7 vols. 70 per cent. to 2 vols. 80 per cent. | Cineol, pinene, cymene, aromadendral, sesquiterpene.                 |
| <i>E. quadrangulata</i>                 | ...                                    | 32                                 | 0.9064                     | +10.7°                   | 1.4625                     | 4.9                    | 2 vols. 70 per cent.                         | Cineol, pinene, sesquiterpene.                                       |
| <i>E. radiata</i>                       | ...                                    | Traces                             | 0.8643 to 0.8747.          | -59.75° to -77.7°.       | 1.4777 to 1.4806.          | 4.4 to 8.4.            | Insoluble                                    | Phellandrene, pinene, cineol, piperitone, piperitol, esters.         |
| <i>E. redunda</i>                       | ...                                    | 38                                 | 0.9097                     | +13.5°                   | 1.4663                     | 2.4                    | 6 vols. 70 per cent.                         | Cineol, pinene, sesquiterpene.                                       |
| <i>E. regnans</i>                       | ...                                    | Nil.                               | 0.8802 to 0.8879.          | -24.4° to -31.1°.        | 1.4882 to 1.4901.          | 13.2 to 15.4.          | 5 vols. 80 per cent.                         | Phellandrene, eudesmol, geraniol, esters, piperitone, sesquiterpene. |
| <i>E. resinifera</i>                    | ...                                    | 50                                 | 0.9098                     | +2.25°                   | 1.4698                     | 9.2                    | 1½ vols. 70 per cent.                        | Cineol, pinene, sesquiterpene, esters.                               |
| <i>E. Risdoni</i>                       | ...                                    | 46                                 | 0.9045 to 0.9079.          | -9.9° to -14.6°.         | 1.4656 to 1.4677.          | 21.1 to 23.8.          | 3 vols. 70 per cent. to 5 vols. 70 per cent. | Cineol, phellandrene, piperitone, esters, amyl-alcohol.              |
| <i>E. robusta</i>                       | ...                                    | 5 to 10T.                          | 0.8777                     | +4.0°                    | 1.4744                     | 9.1                    | 8 vols. 80 per cent.                         | Pinene, sesquiterpene, cineol, esters.                               |
| <i>E. Rodwayi</i>                       | ...                                    | 50                                 | 0.9075                     | +10.6°                   | 1.4671                     | 3.96                   | 6 vols. 70 per cent.                         | Cineol, pinene, liquid eudesmol, sesquiterpene.                      |
| <i>E. Rossii</i>                        | ...                                    | 40                                 | 0.9168 to 0.9243.          | +7.2° to +9.8°.          | 1.4684                     | 7.9                    | 1½ vols. 70 per cent.                        | Cineol, pinene, piperitone, liquid eudesmol, sesquiterpene.          |
| <i>E. rostrata</i>                      | ...                                    | 10T.                               | 0.8955 to 0.9047.          | -11.8° to -14.5°.        | 1.4839 to 1.4890.          | 6.1 to 10.6.           | 1 vol. 80 per cent. to 2 vols. 80 per cent.  | Cineol, pinene, phellandrene, cymene, aromadendral.                  |
| <i>E. rostrata</i> var. <i>borealis</i> | ...                                    | 46                                 | 0.9065 to 0.9153.          | +3.5° to +5.46°.         | 1.4654                     | 4.8 to 6.6.            | 1¼ to 1½ vols. 70 per cent.                  | Cineol, pinene, sesquiterpene.                                       |
| <i>E. rubida</i>                        | ...                                    | 15T.                               | 0.9067 to 0.9209.          | -1.1° to +4.4°           | 1.4892                     | 3.2 to 12.3            | Insoluble                                    | Pinene, cineol, phellandrene, esters, sesquiterpene.                 |
| <i>E. Rudderi</i>                       | ...                                    | 5T.                                | 0.9042                     | -8.5°                    | 1.4841                     | 6.1                    | 1 vol. 80 per cent.                          | Pinene, cymene, aromadendral, cineol.                                |
| <i>E. rudis</i>                         | ...                                    | 38                                 | 0.9068                     | +10.1°                   | 1.4695                     | 3.2                    | 1 vol. 80 per cent.                          | Pinene, cineol, sesquiterpene, volatile aldehydes.                   |

|                                                | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $\alpha_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                       | Principal Constituents.                                          |
|------------------------------------------------|----------------------------------------|------------------------------------|----------------------------|-------------------------------|----------------------------|------------------------|----------------------------------------------|------------------------------------------------------------------|
|                                                | In original oils when first distilled. | In same oils after about 20 years. |                            |                               |                            |                        |                                              |                                                                  |
| <i>E. Rydalenensis</i>                         | 8R.                                    | ...                                | 0.8854                     | +24.7°                        | 1.4717                     | 44.0                   | Insoluble                                    | Pinene, cineol, geranyl-acetate, sesquiterpene.                  |
| <i>E. saligna</i> var. <i>pallidivalvis</i> .. | 5 to 10T.                              | ...                                | 0.8860 to 0.8937.          | +32.4° to +34.5°.             | 1.4703                     | 28.9 to 30.6.          | 7 vols. 80 per cent. to 9 vols. 80 per cent. | Pinene, esters, amyl-alcohol. alcoholic bodies, sesquiterpene.   |
| <i>E. saligna</i>                              | Traces                                 | ...                                | 0.8731 to 0.8846.          | +1.1°                         | 1.4789 to 1.4795.          | 26.2 to 35.5           | 10 vols. 80 p. r cent.                       | Pinene, cymene, esters, sesquiterpen.                            |
| <i>E. salomonophloia</i>                       | 48                                     | ...                                | 0.9076                     | +6.3°                         | 1.4681                     | 4.9                    | 3½ vols. 70 per cent.                        | Pinene, cineol, aromadendral, sesquiterpene.                     |
| <i>E. salubris</i>                             | 10                                     | ...                                | 0.902                      | —5.8°                         | 1.4784                     | 18.9                   | 1 vol. 80 per cent.                          | Pinene, cymene, aromadendral, esters, cineol, sesquiterpene.     |
| <i>E. santalifolia</i>                         | 12R.                                   | ...                                | 0.884                      | —37.7°                        | 1.4736                     | 4.9                    | 8 vols. 80 per cent.                         | Limonene, pinene, cineol, sesquiterpene.                         |
| <i>E. Seeana</i>                               | 52                                     | 58                                 | 0.910                      | +5.6°                         | 1.4649                     | 5.5                    | 1¼ vols. 70 per cent.                        | Cineol, pinene, sesquiterpene.                                   |
| <i>E. siderophloia</i>                         | Traces                                 | ...                                | 0.9067                     | +14.5°                        | 1.4943                     | 4                      | Insoluble                                    | Pinene, phellandrene, alcoholic bodies, sesquiterpene.           |
| <i>E. sideroxylon</i>                          | 60                                     | 65                                 | 0.9189 to 0.9227.          | +1.4° to +3.2°.               | 1.4668                     | 2.5                    | 1¼ vols. 70 per cent.                        | Cineol, pinene, sesquiterpene.                                   |
| <i>E. Sieberiana</i>                           | 8T.                                    | 11R.                               | 0.8880                     | —43.3°                        | 1.4829                     | 2.5                    | Insoluble                                    | Phellandrene, piperitone, cineol, cymene, sesquiterpene.         |
| <i>E. Smithii</i>                              | 70                                     | ...                                | 0.9133 to 0.9192.          | +4.7° to +6.4°.               | 1.4616 to 1.4672.          | 2.4                    | 1¼ vols. 70 per cent.                        | Cineol, pinene, eudesmol, paraffin.                              |
| <i>E. squamosa</i>                             | 56                                     | 70                                 | 0.9182                     | Inactive                      | 1.4635                     | 5.5                    | 1¼ vols. 70 per cent.                        | Cineol, pinene, aromadendral, sesquiterpene, volatile aldehydes. |
| <i>E. Staigeriana</i>                          | Nil.                                   | ...                                | 0.8715                     | —37.53°                       | 1.4814                     | 8.6                    | 8 vols. 80 per cent.                         | Limonene, citral, geranyl-acetate, free geraniol, sesquiterpene. |
| <i>E. stellulata</i>                           | 5T.                                    | 8R.                                | 0.871                      | —22.7°                        | 1.4845                     | 2.1                    | Insoluble                                    | Phellandrene, cineol, sesquiterpene.                             |
| <i>E. stricta</i>                              | 58                                     | 66                                 | 0.9246                     | —0.35°                        | 1.4654                     | 2.5                    | 1¼ vols. 70 per cent.                        | Cineol, pinene, eudesmol, aromadendral.                          |
| <i>E. Stuartiana</i>                           | 53                                     | ...                                | 0.916                      | +4.8°                         | 1.4652                     | 14.2                   | 1¼ vols. 70 per cent.                        | Cineol, pinene, esters, sesquiterpene.                           |



|                                                    | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $\alpha_D$ | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol.                      | Principal Constituents.                                                        |
|----------------------------------------------------|----------------------------------------|------------------------------------|----------------------------|-----------------------------|----------------------------|------------------------|---------------------------------------------|--------------------------------------------------------------------------------|
|                                                    | In original oils when first distilled. | In same oils after about 20 years. |                            |                             |                            |                        |                                             |                                                                                |
| <i>E. Stuartiana</i> var. <i>cordata</i> ...       | 50                                     | ...                                | 0.934                      | +4.0°                       | 1.4652                     | 35.2                   | 1½ vols. 70 per cent.                       | Cineol, pinene, esters, sesquiterpene.                                         |
| <i>E. tenuola</i> ...                              | 7R.                                    | ...                                | 0.8864                     | -27.6°                      | 1.4858                     | 3.2                    | 5 vols. 80 per cent.                        | Phellandrene, cineol, piperitone, eudesmol, sesquiterpene.                     |
| <i>E. terebinthina</i> ...                         | 18                                     | ...                                | 0.9158 to 0.9128.          | -9.4° to -11.8°             | 1.4877 to 1.4906.          | 26.7                   | 1 vol. 80 per cent.                         | Pinene, cymene, cineol, aromadendral, sesquiterpene.                           |
| <i>E. terebinthina</i> var. <i>cineolifera</i> ... | 51                                     | ...                                | 0.9075 to 0.9112.          | +0.6° to +1.5°              | 1.4679 to 1.4703.          | 3.7                    | 1½ vols. 70 per cent.                       | Cineol, pinene, aromadendral, sesquiterpene.                                   |
| <i>E. tessellaris</i> ...                          | 5 to 10T.                              | ...                                | 0.8757                     | +8.6                        | 1.4824                     | 6.2                    | Insoluble                                   | Pinene, cymene, cineol, sesquiterpene.                                         |
| <i>E. trachyphloia</i> ...                         | Traces                                 | ...                                | 0.8873 to 0.8929.          | +8.4° to +9.8°              | 1.4844                     | 3.2                    | Insoluble                                   | Pinene, sesquiterpene, aromadendral.                                           |
| <i>E. umbra</i> ...                                | 28                                     | 35                                 | 0.8970                     | +18.7°                      | 1.4639                     | 7.1                    | 5 vols. 80 per cent.                        | Pinene, cineol, sesquiterpene.                                                 |
| <i>E. uncinata</i> ...                             | 20                                     | ...                                | 0.9111                     | -2.4°                       | 1.4754                     | 13.5                   | 4½ vols. 70 per cent.                       | Pinene, cineol, cymene, aromadendral, alcoholic bodies, esters, sesquiterpene. |
| <i>E. unialata</i> ...                             | 54                                     | ...                                | 0.9179                     | +3.1°                       | 1.4681                     | 11.1                   | 1½ vols. 70 per cent.                       | Cineol, pinene, esters, paraffin, sesquiterpene.                               |
| <i>E. urnigera</i> ...                             | 53                                     | ...                                | 0.9088                     | +11.8°                      | 1.4652                     | 18.3                   | 5 vols. 70 per cent.                        | Cineol, pinene, esters, volatile aldehydes, sesquiterpene.                     |
| <i>E. vernicosa</i> ...                            | 52                                     | ...                                | 0.9038                     | +11.3°                      | 1.4642                     | 5.9                    | 1 vol. 80 per cent.                         | Cineol, pinene, volatile aldehydes.                                            |
| <i>E. viminalis</i> ...                            | 28                                     | 50                                 | 0.9044 to 0.9162.          | +3.7° to +4.2°              | 1.4707 to 1.4798.          | 6.1 to 9.5             | 1 vol. 80 per cent. to 2 vols. 80 per cent. | Pinene, phellandrene, cineol, sesquiterpene.                                   |
| <i>E. viminalis</i> var. (a) ...                   | 46                                     | 58                                 | 0.9122 to 0.9141.          | +6.2° to +6.7°              | 1.4655                     | 3.4 to 4.6             | 1½ vols. 70 per cent.                       | Cineol, pinene, (?) benzaldehyde, sesquiterpene.                               |
| <i>E. virgata</i> ...                              | Traces                                 | ...                                | 0.8883 to 0.9154.          | -20.9°                      | 1.4810 to 1.4958.          | 3.3 to 5.7             | 1 vol. 80 per cent. to 3 vols. 80 per cent. | Phellandrene, eudesmol, cineol, piperitone, sesquiterpene.                     |
| <i>E. viridis</i> ...                              | 10T.                                   | 10R.                               | 0.9006                     | -8.1°                       | 1.4771                     | 5.7                    | 2 vols. 80 per cent.                        | Pinene, cineol, aromadendral, sesquiterpene.                                   |

|                         | Cineol Percentages.                    |                                    | Specific Gravity at 15° C. | Optical Rotation $a_D$ . | Refractive Index at 20° C. | Saponification Number. | Solubility in Alcohol. | Principal Constituents.                                  |
|-------------------------|----------------------------------------|------------------------------------|----------------------------|--------------------------|----------------------------|------------------------|------------------------|----------------------------------------------------------|
|                         | In original oils when first distilled. | In some oils after about 20 years. |                            |                          |                            |                        |                        |                                                          |
| <i>E. vitrea</i>        | 20                                     | 22                                 | 0.8860                     | -30.1°                   | 1.4771                     | 5.4                    | 1 vol. 80 per cent.    | Phellandrene, cineol, citral, pipéritone, sesquiterpene. |
| <i>E. Wilkinsoniana</i> | 15T.                                   | 21P.                               | 0.8944                     | -21.4°                   | 1.4717                     | 5.0                    | Insoluble              | Pinene, cineol, sesquiterpene.                           |
| <i>E. Woolstiana</i>    | 10                                     | ...                                | 0.8890 to 0.9051.          | -0.5° to -15.8°          | 1.4838                     | 9.1                    | 1 vol. 80 per cent.    | Pinene, cineol, cymene, aromadendral, sesquiterpene.     |

## Average Yields of Oil from the Several Species of Eucalyptus included in this work.

CONSIDERED broadly the variation in the amounts of oil obtainable from the leaves of any particular species of Eucalyptus depends largely on the season and on the condition of growth of the material employed. In times of drought the secretion of oil appears to diminish, or else it is used up in the struggle for existence, but after an abundance of rain the trees soon again yield the normal amount of oil.

Under ordinary conditions the larger quantity occurs in the spring and early summer, when the growth is more vigorous, falling again during the winter months, and with most of the cineol oil-producing species the product becomes correspondingly richer in that constituent as the oil decreases in amount. Not only is this the case with the oil while in the leaf, but even after extraction an increase in cineol has been observed, more particularly with oils derived from species belonging to one well-defined group. Several instances of this increase in cineol after extraction will be found recorded in this work.

The identity of the constituent responsible for this alteration is not at present clear, although the change is apparent mostly in those oils in which the formation of the insoluble deposit has been observed. This question is more fully considered in the article dealing with this deposit.

The increased yield is usually associated with an increase in the terpenes characteristic of the oil of the species, as pinene in the pinene-cineol oils, phellandrene and pinene in the phellandrene-pinene-cineol oils; and phellandrene in the phellandrene-cineol oils.

The yield of oil from the "suckers" or adventitious shoots is, with many species, greater than from the mature lanceolate leaves, and in some cases this increase is considerable. The constituents characteristic of the oil of a particular species are, as a rule, also those of the product from the abnormal growth, a fact of considerable economic importance.

In a paper (Proc. Roy. Soc. Vic. XII, 10, and Pharm. Journ. 3, 5, 270), Mr. Bosisto deals with the problem, whether the Eucalyptus is a fever-destroying tree. In this paper he calculates the probable amount of oil in gallons existing in these trees over a large area of country at any one time. But when we consider the varying amounts of oil contained in the leaves of the several species such approximations must be merely guesses. By referring to the table of yields it will be seen that the oil obtainable from the various species ranges from 3.5 per cent. down to practically nothing; so that without a fair approximation of the extent or range of the various species is determined, it appears hopeless to attempt to solve the problem of available supply by this method. That it is practically unlimited in Australia we readily admit, and also that cineol oils conforming to the British Pharmacopœia standard can be produced in any quantity required. This statement is also true for the phellandrene oils. It cannot but be observed what a great variety of oils are obtainable from the several Eucalyptus



species, and how large a proportion of these contain a predominance of terpenes, principally pinene and phellandrene. The yield from trees giving terpene oils is often large, especially those in which phellandrene predominates, and this fact has naturally led to the exploitation of these species for mineral separation and other industrial purposes.

By referring to the table it will be seen that such species as *E. polybractea*, *E. Morrisii*, *E. Smithii*, *E. cordata*, &c., all of which yield oils rich in cineol, almost hold their own, in regard to yields, with many of the "peppermint" or phellandrene-bearing species.

It is to be expected that the yields of oil will influence largely the commercial consideration of distillation, and for this reason we append the following table, which in almost every case records the results of our own distillations; included are a few the authenticity of which there is no doubt. The figures given represent the mean of the results obtained with the leaves of any individual species recorded in the list, and in many cases these spread over more than twenty-five years. The leaves and terminal branchlets were taken in all instances as would be done for distillation on a commercial scale, and the leaves in all cases were as fresh as it was possible to obtain them. Of course, in some instances, evaporation had taken place, as some of the material came hundreds of miles, both by land and sea, packed closely in bags. We have given the average yields in preference to that of any one distillation, because this more nearly represents the actual amount of oil that would be obtained if the species was commercially distilled.

In practically the whole of the species recorded in the table the oil was distilled from the mature leaves and not from abnormal leaves, so that in these cases the results may be considered to represent the minimum yields.

The yield per 1,000 pounds of material has also been calculated, as the statement in pounds and ounces appeals more directly to the commercial world.

|                                             | Per-centage Yield. | Yield per 1,000 lb. of Material. |     |                                | Per-centage Yield. | Yield per 1,000 lb. of Material. |     |
|---------------------------------------------|--------------------|----------------------------------|-----|--------------------------------|--------------------|----------------------------------|-----|
|                                             |                    | lb.                              | oz. |                                |                    | lb.                              | oz. |
| <i>E. Australiana</i> ... ..                | 3.50               | 35                               | 0   | <i>E. linearis</i> ... ..      | 1.50               | 15                               | 0   |
| <i>E. phellandra</i> ... ..                 | 3.50               | 35                               | 0   | <i>E. vitrea</i> ... ..        | 1.50               | 15                               | 0   |
| <i>E. dives</i> ... ..                      | 2.80               | 28                               | 0   | <i>E. salmonophloia</i> ... .. | 1.44               | 14                               | 6   |
| <i>E. polybractea</i> (young leaves)        | 2.50               | 25                               | 0   | <i>E. Risdoni</i> ... ..       | 1.40               | 14                               | 0   |
| <i>E. polybractea</i> (old leaves)          | 1.50               | 15                               | 0   | <i>E. uncinata</i> ... ..      | 1.40               | 14                               | 0   |
| <i>E. Staigeriana</i> ... ..                | 2.48               | 24                               | 8   | <i>E. salubris</i> ... ..      | 1.39               | 13                               | 14  |
| <i>E. cordata</i> ... ..                    | 2.30               | 23                               | 0   | <i>E. camphora</i> ... ..      | 1.34               | 13                               | 6   |
| <i>E. pulverulenta</i> ... ..               | 2.22               | 22                               | 3   | <i>E. Muelleri</i> ... ..      | 1.28               | 12                               | 13  |
| <i>E. odorata</i> ... ..                    | 1.87               | 18                               | 11  | <i>E. Andrewsi</i> ... ..      | 1.27               | 12                               | 11  |
| <i>E. cneorifolia</i> ... ..                | 1.80               | 18                               | 0   | <i>E. Consideniana</i> ... ..  | 1.20               | 12                               | 0   |
| <i>E. amygdalina</i> ... ..                 | 1.80               | 18                               | 0   | <i>E. oreades</i> ... ..       | 1.20               | 12                               | 0   |
| <i>E. Smithii</i> ... ..                    | 1.80               | 18                               | 0   | <i>E. cinerea</i> ... ..       | 1.20               | 12                               | 0   |
| <i>E. Delegatensis</i> ... ..               | 1.70               | 17                               | 0   | <i>E. longicornis</i> ... ..   | 1.20               | 12                               | 0   |
| <i>E. Morrisii</i> ... ..                   | 1.65               | 16                               | 8   | <i>E. cornuta</i> ... ..       | 1.20               | 12                               | 0   |
| <i>E. amygdalina</i> var. <i>nitida</i> ... | 1.60               | 16                               | 0   | <i>E. redunca</i> ... ..       | 1.20               | 12                               | 0   |
| <i>E. pumila</i> ... ..                     | 1.60               | 16                               | 0   | <i>E. phlebophylla</i> ... ..  | 1.20               | 12                               | 0   |
| <i>E. radiata</i> ... ..                    | 1.60               | 16                               | 0   | <i>E. rudis</i> ... ..         | 1.20               | 12                               | 0   |

|                                                | Per-<br>centage<br>Yield. | Yield per<br>1,000 lb. of<br>Material. |                                             | Per-<br>centage<br>Yield. | Yield per<br>1,000 lb. of<br>Material. |
|------------------------------------------------|---------------------------|----------------------------------------|---------------------------------------------|---------------------------|----------------------------------------|
|                                                |                           | lb. oz.                                |                                             |                           | lb. oz.                                |
| <i>E. urnigera</i> ...                         | 1.13                      | 11 5                                   | <i>E. obliqua</i> ...                       | 0.70                      | 7 0                                    |
| <i>E. Stuartiana</i> var. <i>cordata</i> ...   | 1.13                      | 11 5                                   | <i>E. Marsdeni</i> ...                      | 0.70                      | 7 0                                    |
| <i>E. viridis</i> ...                          | 1.10                      | 11 0                                   | <i>E. Gunnii</i> ...                        | 0.68                      | 6 13                                   |
| <i>E. maculosa</i> ...                         | 1.10                      | 11 0                                   | <i>E. quadrangulata</i> ...                 | 0.68                      | 6 13                                   |
| <i>E. oleosa</i> ...                           | 1.10                      | 11 0                                   | <i>E. Bridgesiana</i> ...                   | 0.67                      | 6 11                                   |
| <i>E. Perriniana</i> ...                       | 1.10                      | 11 0                                   | <i>E. tæniola</i> ...                       | 0.66                      | 6 10                                   |
| <i>E. goniocalyx</i> ...                       | 1.00                      | 10 0                                   | <i>E. cosmophylla</i> ...                   | 0.62                      | 6 3                                    |
| <i>E. calycogona</i> ...                       | 1.00                      | 10 0                                   | <i>E. Behriana</i> ...                      | 0.62                      | 6 3                                    |
| <i>E. Maideni</i> ...                          | 1.00                      | 10 0                                   | <i>E. coriacea</i> ...                      | 0.61                      | 6 2                                    |
| <i>E. dumosa</i> ...                           | 1.00                      | 10 0                                   | <i>E. coccifera</i> ...                     | 0.61                      | 6 2                                    |
| <i>E. fraxinoides</i> ...                      | 0.98                      | 9 13                                   | <i>E. Rossii</i> ...                        | 0.61                      | 6 2                                    |
| <i>E. Wilkinsoniana</i> ...                    | 0.98                      | 9 13                                   | <i>E. lævopinea</i> ...                     | 0.61                      | 6 2                                    |
| <i>E. Bosistoana</i> ...                       | 0.97                      | 9 11                                   | <i>E. squamosa</i> ...                      | 0.60                      | 6 0                                    |
| <i>E. occidentalis</i> ...                     | 0.95                      | 9 8                                    | <i>E. Deanei</i> ...                        | 0.60                      | 6 0                                    |
| <i>E. rostrata</i> var. <i>borealis</i> ...    | 0.94                      | 9 6                                    | <i>E. sideroxylon</i> ...                   | 0.60                      | 6 0                                    |
| <i>E. tereticornis</i> var. <i>cineolifera</i> | 0.92                      | 9 3                                    | <i>E. umbra</i> ...                         | 0.60                      | 6 0                                    |
| <i>E. globulys</i> ...                         | 0.92                      | 9 3                                    | <i>E. conica</i> ...                        | 0.59                      | 5 14                                   |
| <i>E. costata</i> ...                          | 0.90                      | 9 0                                    | <i>E. ovalifolia</i> var. <i>lanceolata</i> | 0.58                      | 5 13                                   |
| <i>E. gracilis</i> ...                         | 0.90                      | 9 0                                    | <i>E. hemiphloia</i> ...                    | 0.58                      | 5 13                                   |
| <i>E. unialata</i> ...                         | 0.89                      | 8 14                                   | <i>E. Parramattensis</i> ...                | 0.57                      | 5 11                                   |
| <i>E. melliodora</i> ...                       | 0.87                      | 8 11                                   | <i>E. lactea</i> ...                        | 0.56                      | 5 10                                   |
| <i>E. accedens</i> ...                         | 0.87                      | 8 11                                   | <i>E. viminalis</i> ...                     | 0.55                      | 5 8                                    |
| <i>E. Lehmanni</i> ...                         | 0.86                      | 8 10                                   | <i>E. virgata</i> ...                       | 0.54                      | 5 6                                    |
| <i>E. dealbata</i> ...                         | 0.86                      | 8 10                                   | <i>E. longifolia</i> ...                    | 0.54                      | 5 6                                    |
| <i>E. dextropinea</i> ...                      | 0.85                      | 8 8                                    | <i>E. Nepeanensis</i> ...                   | 0.52                      | 5 3                                    |
| <i>E. campanulata</i> ...                      | 0.85                      | 8 8                                    | <i>E. microcorys</i> ...                    | 0.51                      | 5 2                                    |
| <i>E. bicolor</i> ...                          | 0.85                      | 8 8                                    | <i>E. nova-anglica</i> ...                  | 0.51                      | 5 2                                    |
| <i>E. Blaxlandi</i> ...                        | 0.83                      | 8 5                                    | <i>E. Sieberiana</i> ...                    | 0.50                      | 5 0                                    |
| <i>E. polyanthemos</i> ...                     | 0.83                      | 8 5                                    | <i>E. megacarpa</i> ...                     | 0.50                      | 5 0                                    |
| <i>E. platypus</i> ...                         | 0.82                      | 8 3                                    | <i>E. Woollsiana</i> ...                    | 0.50                      | 5 0                                    |
| <i>E. exserta</i> ...                          | 0.82                      | 8 3                                    | <i>E. tereticornis</i> ...                  | 0.50                      | 5 0                                    |
| <i>E. Baileyana</i> ...                        | 0.82                      | 8 3                                    | <i>E. stricta</i> ...                       | 0.50                      | 5 0                                    |
| <i>E. regnans</i> ...                          | 0.81                      | 8 2                                    | <i>E. Bancrofti</i> ...                     | 0.50                      | 5 0                                    |
| <i>E. piperita</i> ...                         | 0.80                      | 8 0                                    | <i>E. microtheca</i> ...                    | 0.48                      | 4 13                                   |
| <i>E. Moorei</i> ...                           | 0.80                      | 8 0                                    | <i>E. Rodwayi</i> ...                       | 0.48                      | 4 13                                   |
| <i>E. viminalis</i> var. (a) ...               | 0.80                      | 8 0                                    | <i>E. Dalrympleana</i> ...                  | 0.48                      | 4 13                                   |
| <i>E. punctata</i> ...                         | 0.80                      | 8 0                                    | <i>E. eximia</i> ...                        | 0.46                      | 4 10                                   |
| <i>E. diversicolor</i> ...                     | 0.80                      | 8 0                                    | <i>E. hæmastoma</i> ...                     | 0.44                      | 4 6                                    |
| <i>E. vernicosa</i> ...                        | 0.80                      | 8 0                                    | <i>E. resinifera</i> ...                    | 0.42                      | 4 3                                    |
| <i>E. citriodora</i> ...                       | 0.80                      | 8 0                                    | <i>E. santalifolia</i> ...                  | 0.41                      | 4 2                                    |
| <i>E. leucoxylon</i> ...                       | 0.78                      | 7 13                                   | <i>E. cærulea</i> ...                       | 0.40                      | 4 0                                    |
| <i>E. Seeana</i> ...                           | 0.78                      | 7 13                                   | <i>E. Stuartiana</i> ...                    | 0.40                      | 4 0                                    |
| <i>E. populifolia</i> ...                      | 0.76                      | 7 10                                   | <i>E. Gullicki</i> ...                      | 0.38                      | 3 13                                   |
| <i>E. elæophora</i> ...                        | 0.75                      | 7 8                                    | <i>E. hemilampra</i> ...                    | 0.37                      | 3 11                                   |
| <i>E. eugenioides</i> ...                      | 0.75                      | 7 8                                    | <i>E. Laseroni</i> ...                      | 0.37                      | 3 11                                   |
| <i>E. apiculata</i> ...                        | 0.70                      | 7 0                                    | <i>E. alpina</i> ...                        | 0.36                      | 3 10                                   |
| <i>E. parvifolia</i> ...                       | 0.70                      | 7 0                                    | <i>E. Bæuerleni</i> ...                     | 0.33                      | 3 5                                    |

|                                                      | Per-<br>centage<br>Yield. | Yield per<br>1,000 lb. of<br>Material. |                                                                                            | Per-<br>centage<br>Yield. | Yield per<br>1,000 lb. of<br>Material. |
|------------------------------------------------------|---------------------------|----------------------------------------|--------------------------------------------------------------------------------------------|---------------------------|----------------------------------------|
|                                                      |                           | lb. oz.                                |                                                                                            |                           | lb. oz.                                |
| <i>E. Rudderi</i> ... ..                             | 0·31                      | 3 2                                    | <i>E. crebra</i> ... ..                                                                    | 0·16                      | 1 10                                   |
| <i>E. Fletcheri</i> ... ..                           | 0·30                      | 3 0                                    | <i>E. robusta</i> ... ..                                                                   | 0·16                      | 1 10                                   |
| <i>E. Luehmanniana</i> ... ..                        | 0·30                      | 3 0                                    | <i>E. carnea</i> ... ..                                                                    | 0·16                      | 1 10                                   |
| <i>E. stellulata</i> ... ..                          | 0·30                      | 3 0                                    | <i>E. Irbyi</i> ... ..                                                                     | 0·15                      | 1 8                                    |
| <i>E. macrorhyncha</i> ... ..                        | 0·29                      | 2 14                                   | <i>E. intermedia</i> ... ..                                                                | 0·13                      | 1 5                                    |
| <i>E. punctata</i> var. <i>didyma</i> ... ..         | 0·28                      | 2 13                                   | <i>E. saligna</i> ... ..                                                                   | 0·12                      | 1 3                                    |
| <i>E. ovalifolia</i> ... ..                          | 0·27                      | 2 11                                   | <i>E. ligustrina</i> ... ..                                                                | 0·12                      | 1 3                                    |
| <i>E. rostrata</i> ... ..                            | 0·27                      | 2 11                                   | <i>E. fastigata</i> ... ..                                                                 | 0·12                      | 1 3                                    |
| <i>E. affinis</i> ... ..                             | 0·26                      | 2 10                                   | <i>E. capitellata</i> ... ..                                                               | 0·11                      | 1 2                                    |
| <i>E. Rydalensis</i> ... ..                          | 0·26                      | 2 10                                   | <i>E. pilularis</i> ... ..                                                                 | 0·11                      | 1 2                                    |
| <i>E. saligna</i> var. <i>pallidivalvis</i> ... ..   | 0·26                      | 2 10                                   | <i>E. botryoides</i> ... ..                                                                | 0·11                      | 1 2                                    |
| <i>E. patentinervis</i> ... ..                       | 0·26                      | 2 10                                   | <i>E. melanophloia</i> ... ..                                                              | 0·11                      | 1 2                                    |
| <i>E. calophylla</i> ... ..                          | 0·25                      | 2 8                                    | <i>E. albens</i> ... ..                                                                    | 0·11                      | 1 2                                    |
| <i>E. paludosa</i> ... ..                            | 0·24                      | 2 6                                    | <i>E. paniculata</i> ... ..                                                                | 0·10                      | 1 0                                    |
| <i>E. propinqua</i> ... ..                           | 0·24                      | 2 6                                    | <i>E. corynocalyx</i> ... ..                                                               | 0·10                      | 1 0                                    |
| <i>E. maculata</i> ... ..                            | 0·23                      | 2 5                                    | <i>E. acmenioides</i> ... ..                                                               | 0·09                      | 0 14                                   |
| <i>E. marginata</i> ... ..                           | 0·22                      | 0 3                                    | <i>E. rubida</i> ... ..                                                                    | 0·07                      | 0 11                                   |
| <i>E. acervula</i> ... ..                            | 0·22                      | 2 3                                    | <i>E. corymbosa</i> ... ..                                                                 | 0·06                      | 0 10                                   |
| <i>E. Macarthuri</i> (including<br>Bark oil). ... .. | 0·21                      | 2 2                                    | <i>E. siderophloia</i> ... ..                                                              | 0·06                      | 0 10                                   |
| <i>E. acaciæformis</i> ... ..                        | 0·20                      | 2 2                                    | <i>E. aggregata</i> ... ..                                                                 | 0·04                      | 0 6                                    |
| <i>E. trachyphloia</i> ... ..                        | 0·20                      | 2 0                                    | <i>E. nigra</i> ... ..                                                                     | 0·04                      | 0 6                                    |
| <i>E. intertexta</i> ... ..                          | 0·20                      | 2 0                                    | <i>E. gomphocephala</i> ... ..                                                             | 0·03                      | 0 5                                    |
| <i>E. angophoroides</i> ... ..                       | 0·19                      | 1 14                                   | <i>E. fasciculosa</i> ... ..                                                               | 0·02                      | 0 3                                    |
| <i>E. Dawsoni</i> ... ..                             | 0·18                      | 1 13                                   | <i>E. Planchoniana</i> ... ..                                                              | 0·02                      | 0 3                                    |
| <i>E. tessellaris</i> ... ..                         | 0·16                      | 1 10                                   | <i>E. obtusiflora</i> and <i>E. terminalis</i> did not yield<br>sufficient oil to collect. |                           |                                        |



## The Alteration in Specific Gravity of Eucalyptus Oils at Various Temperatures.

As considerable differences occur in the specific gravities of Eucalyptus oils at various temperatures, it was necessary that some standard be established whereby the several oils might be brought into uniformity. In Sydney the temperature during the summer months is usually high, and the ordinary temperature in the laboratory at that period is often  $26^{\circ}\text{C}$ . To reduce the oils to a standard temperature by artificial means was out of the question. It was decided, therefore, to determine the increase or decrease for varying degrees of temperature within ordinary working limits. A special pyknometer was constructed with a fine capillary, standardised at  $15^{\circ}\text{C}$ ., and the specific gravity determined at the temperatures given below, the figures being restricted to four places of decimals. The following results were obtained, experimentally, with a Eucalyptus oil rich in cineol, and having a specific gravity 0.9156 at  $15^{\circ}\text{C}$ . :—

|                                                     |                                                  |
|-----------------------------------------------------|--------------------------------------------------|
| At $10^{\circ}\text{C}$ . specific gravity = 0.9190 | $17^{\circ}\text{C}$ . specific gravity = 0.9141 |
| $12^{\circ}\text{C}$ . „ = 0.9179                   | $19^{\circ}\text{C}$ . „ = 0.9126                |
| $14^{\circ}\text{C}$ . „ = 0.9166                   | $22^{\circ}\text{C}$ . „ = 0.9107                |
| $15^{\circ}\text{C}$ . „ = 0.9156                   | $26^{\circ}\text{C}$ . „ = 0.9074                |

From these results it is seen that 0.00075 is practically the increase between  $10^{\circ}$  and  $15^{\circ}\text{C}$ ., and that the same figures represent the decrease between  $15^{\circ}$  and  $26^{\circ}\text{C}$ . Taking the standard specific gravity at  $15^{\circ}\text{C}$ ., and calculating either upwards or downwards, as the case may be, the following figures are obtained, and it is seen that they differ but little from those determined experimentally :—

|                                                      |                                                   |
|------------------------------------------------------|---------------------------------------------------|
| At $10^{\circ}\text{C}$ . specific gravity = 0.91935 | $19^{\circ}\text{C}$ . specific gravity = 0.91260 |
| $11^{\circ}\text{C}$ . „ = 0.91860                   | $20^{\circ}\text{C}$ . „ = 0.91185                |
| $12^{\circ}\text{C}$ . „ = 0.91785                   | $21^{\circ}\text{C}$ . „ = 0.91110                |
| $13^{\circ}\text{C}$ . „ = 0.91710                   | $22^{\circ}\text{C}$ . „ = 0.91035                |
| $14^{\circ}\text{C}$ . „ = 0.91635                   | $23^{\circ}\text{C}$ . „ = 0.90960                |
| $15^{\circ}\text{C}$ . „ = 0.91560                   | $24^{\circ}\text{C}$ . „ = 0.90885                |
| $16^{\circ}\text{C}$ . „ = 0.91485                   | $25^{\circ}\text{C}$ . „ = 0.90810                |
| $17^{\circ}\text{C}$ . „ = 0.91410                   | $26^{\circ}\text{C}$ . „ = 0.90735                |
| $18^{\circ}\text{C}$ . „ = 0.91335                   |                                                   |

For all practical purposes, therefore, 0.00075 may be taken as the increase or decrease, as the case may be, for Eucalyptus oils within the range of ordinary temperatures in the laboratory, and in this way the specific gravity at  $15^{\circ}\text{C}$ . may be calculated for any Eucalyptus oil, providing the apparatus had been standardised for  $15^{\circ}\text{C}$ . These figures have been repeatedly checked during this research, and have been found to agree very well for all those Eucalyptus oils so tested. It is thus easy to determine the specific gravity of a Eucalyptus oil for  $15^{\circ}\text{C}$ . If, for instance, the specific gravity was found to be 0.9095 and the temperature  $21^{\circ}\text{C}$ ., then by adding 0.0045 we obtain 0.9140 as the corrected specific gravity for the particular sample at  $15^{\circ}\text{C}$ .

Taking advantage of the colder weather in June, determinations were made with two Eucalyptus oils belonging to different classes, in order to test the accuracy of the differences recorded above. A specific gravity bottle holding 50 grams of water was employed for the purpose, and the temperature of the oil increased to the desired degree by artificial means. The crude oil of *E. Smithii*

was taken to represent an oil rich in cineol, and a commercial sample of the "Narrow-leaf Peppermint" to represent an oil containing much terpene, and only about 30 per cent. of cineol. The laboratory temperature of the crude oil of *E. Smithii* was 15.5° C., and the determinations made with it gave the following results :—

|             |                  |          |                          |
|-------------|------------------|----------|--------------------------|
| At 15.5° C. | specific gravity | = 0.9197 |                          |
| 18.0° C.    | "                | = 0.9177 | —theory requires 0.91783 |
| 21.0° C.    | "                | = 0.9154 | " 0.91558                |
| 25.0° C.    | "                | = 0.9125 | " 0.91258                |
| 28.5° C.    | "                | = 0.9097 | " 0.90995                |

The oil from the "Narrow-leaf Peppermint" had a temperature of 16° C., and gave the following results :—

|             |                  |           |                          |
|-------------|------------------|-----------|--------------------------|
| At 16.0° C. | specific gravity | = 0.8960. |                          |
| 18.0° C.    | "                | = 0.8943  | — theory requires 0.8945 |
| 20.0° C.    | "                | = 0.8929  | " 0.8930                 |
| 22.0° C.    | "                | = 0.8911  | " 0.8915                 |
| 27.5° C.    | "                | = 0.8874  | " 0.8874                 |

It is thus seen that the difference 0.00075 for each degree of temperature may be safely used for corrections of specific gravity for all Eucalyptus oils under ordinary conditions, and it has been used for the needed corrections in this work. If a standard for specific gravity of Eucalyptus oil be insisted upon, it is necessary that it be stated at a uniform temperature, and 15° C. has been chosen as probably the most useful for the purpose, although, as can be readily seen, any other convenient temperature would suit just as well.

For the purposes of the distiller, or those dealing in Eucalyptus oils, a hydrometer standardised for liquids lighter than water might be employed, the temperatures being taken with a centigrade thermometer. The necessary corrections for 15° C. could then readily be calculated as shown above.

## The Alteration in the Refractive Index of Ordinary Eucalyptus Oils under the Influence of Changes of Temperature.

THE apparatus employed was a Zeiss-Abbé Refractometer with heatable prisms, and water at the stated temperatures was run through the machine for one half hour before final reading. The three species chosen may be considered as representative of the main groups of commercial oils.

### (a) OIL OF *E. AUSTRALIANA*. (First hour oil.)

|             |          |                                                           |
|-------------|----------|-----------------------------------------------------------|
| At 22.5° C. | = 1.4610 | } Mean alteration for each degree, approximately 0.00047. |
| 35.5° C.    | = 1.4550 |                                                           |
| 33.0° C.    | = 1.4561 |                                                           |
| 32.0° C.    | = 1.4566 |                                                           |
| 31.0° C.    | = 1.4571 |                                                           |
| 30.0° C.    | = 1.4575 |                                                           |



(b) OIL OF *E. POLYBRACTEA*.

|                      |                                                                 |
|----------------------|-----------------------------------------------------------------|
| At 22.5° C. = 1.4572 | } Mean alteration for each<br>degree, approximately<br>0.00047. |
| 42.0° C. = 1.4481    |                                                                 |
| 40.0° C. = 1.4491    |                                                                 |
| 30.0° C. = 1.4537    |                                                                 |

(c) OIL OF *E. DIVES*.

|                      |                                                                 |
|----------------------|-----------------------------------------------------------------|
| At 20.0° C. = 1.4793 | } Mean alteration for each<br>degree, approximately<br>0.00047. |
| 39.0° C. = 1.4706    |                                                                 |
| 37.0° C. = 1.4713    |                                                                 |
| 34.0° C. = 1.4727    |                                                                 |
| 31.0° C. = 1.4741    |                                                                 |

The above results indicate that 0.00047 is the mean alteration in refractive index for each degree of temperature for ordinary Eucalyptus oils, and this correction has been employed in this work for standardising the oils at 20° C.

## Eucalyptus Oils and their Constituents.

THE constituents detected in Eucalyptus oils now number about forty. Many of them, however, are identical with similar substances occurring in other essential oils, and are thus obtainable from other sources, although, with several of them, much less advantageously.

The following list includes practically all the constituents so far determined, many of which have been brought to light during these researches. They are found in the oils of the different Eucalypts in varying quantity, occurring more abundantly in some species than in others. It is now known, however, from which investigated species the desired constituents can be most readily obtained, and in the greatest quantity, particularly as those characteristic of specific oils are comparatively constant.

Although the main constituents in the several oils have been determined, yet, in many cases, it is difficult to say with certainty that all have been detected, and it is possible that some do occur in small amounts in the oils of species in which they have not, so far, been found.

During the last twenty-five years, however, much work has been done upon the products of the Eucalypts, and our knowledge concerning the constitution of their oils is now such that it has been possible to evolve some order with the several members of this extensive genus.

### EARLIER INVESTIGATIONS.

The first investigation of a Eucalyptus oil was undertaken by M. Cloëz (Compt. Rend., 1870, p. 687) upon the oil of *E. globulus*. Trees of this species of Eucalyptus had for some years previously been successfully cultivated in many parts of Europe, although the young shoots of the trees grown at Paris did not withstand the frost, and it was due to this circumstance that Cloëz was led to investigate the essential oil obtainable from the leaves. It was from this



investigation that the name Eucalyptol was derived, it being given to the portion of the oil distilling at about  $175^{\circ}\text{C}$ .; and although, in the light of subsequent research his results were not strictly correct, yet the facts therein submitted are interesting and valuable, particularly for the following reasons:—

1. He mentions that he obtained the oil from both green and dry leaves, and also from material from Melbourne, and that the oil distilled under these different conditions was always similar, thus indicating the practical constancy of constituents in the oil of identical species of Eucalyptus.
2. On passing hydrochloric acid gas into the oil, he obtained a crystalline mass, the liquid portion becoming of a beautiful blue-violet colour. Although Cloëz did not follow the matter up, it is now known that this colour reaction was due to the presence in the oil of the sesquiterpene (aromadendrene). This blue-violet colour is always obtained when this sesquiterpene is treated with the halogen acids.

Homeyer (Arch. Pharm. (3) v., p. 293), soon after Cloëz's research came to very different conclusions on examining 3 kilos of a Eucalyptus oil, the specific gravity of which was 0.8762 at  $12^{\circ}\text{C}$ . This oil had probably been distilled from *E. dives* or *E. radiata*, species which were, at that time, looked upon as forms of *E. amygdalina*. This is probably the first time that a difficulty was experienced in arranging results by different observers on Eucalyptus oils, and was due to the products having been obtained from species belonging to distinct groups of these trees.

The correct placing of Eucalyptol chemically was due to E. Jahns (Ber. 17, 2941), who isolated it fairly pure (specific gravity 0.923 at  $16^{\circ}\text{C}$ . and B.P.  $176\text{--}177^{\circ}\text{C}$ .), from the compound it forms with dry hydrochloric acid gas. He also showed its analogy with cineol, and that its formula was  $\text{C}_{10}\text{H}_{18}\text{O}$ .

M. R. Voiry (Compt. Rend. 1888, p. 1419) describes a method for the preparation of pure Eucalyptol (cineol) by freezing it out of the oil. He also states that from the oil of *E. globulus* were obtained both acetic and formic acids, and shows that both butyric and valeric aldehydes also occur.

Although these aldehydes, which are very irritating when inhaled, are present in most crude Eucalyptus oils, yet, like the other constituents, they occur in varying amounts, being most pronounced in those cineol-pinene oils in which the corresponding esters occur in greatest quantity, such for instance as those of *E. cinerea*, *E. goniocalyx*, *E. Maideni*, &c.

The presence of both ethyl and amyl alcohols was determined by Bouchardat and Olivier (Bull. Soc. Chim. III. 9, p. 429) in the lower-boiling portions of Eucalyptus oil. To these may now be added methyl, iso-butyl and normal butyl alcohols which have been determined during these investigations.

Numerous articles dealing with the special study of several of the constituents of Eucalyptus oils are here appended; such are those relating to cineol, geraniol, terpineol, piperitol, eudesmol, the monohydric alcohols, the cyclic (aromatic) aldehydes, citral, citronellal, piperitone, the phenols, the free acids, the various esters, the terpenes (such as pinene, phellandrene, terpinene), the sesquiterpene, and the paraffin stearoptene.

The remaining constituents, also enumerated in the following list, usually occur in small amount, although some of them are quite of frequent occurrence, as, for instance, cymene, and the lower-boiling aldehydes. Although these constituents are not here treated separately, they will be found enumerated under the particular species in the oil of which they occur.

The list of constituents so far determined in Eucalyptus oils is as follow :—

| Cineol (or Eucalyptol)    | Oxide.     |                                           |                    |
|---------------------------|------------|-------------------------------------------|--------------------|
| *Geraniol ... ..          | Alcohols.  | *Tasmanol ... ..                          | Phenols.           |
| Terpineol ... ..          |            | *Australol ... ..                         |                    |
| *Piperitol ... ..         |            | Acetic acid ... ..                        | Free acids.        |
| Globuol... ..             |            | Formic acid ... ..                        |                    |
| Pinocarveol ... ..        |            | *Geranyl-acetate ... ..                   | Esters.            |
| *Eudesmol ... ..          |            | *Butyl-butyrate ... ..                    |                    |
| *Methyl Alcohol ... ..    |            | *Amyl-eudesmate ... ..                    |                    |
| Ethyl alcohol ... ..      |            | *Amyl-phenylacetate ? ..                  |                    |
| *Butyl alcohol ... ..     |            | *Valeric acid ester ... ..                |                    |
| *Iso-butyl alcohol ... .. |            | Terpinyl-acetate ... ..                   |                    |
| Iso-amyl alcohol ... ..   |            | Terpinyl-butyrate ... ..                  |                    |
| Cuminal ... ..            | Aldehydes. | Pinene ... ..                             | Terpenes.          |
| *Aromadendral... ..       |            | Phellandrene ... ..                       |                    |
| *Cryptal... ..            |            | Limonene ... ..                           |                    |
| *Phellandral ? ... ..     |            | Dipentene ... ..                          |                    |
| Citral ... ..             |            | *Terpinene ... ..                         |                    |
| Citronellal ... ..        |            | *Aromadendrene ... ..                     | Sesquiterpene.     |
| Butaldehyde ... ..        |            | Cymene... ..                              | Alkyl benzene.     |
| Valeraldehyde... ..       |            | *Paraffin... ..                           | Solid hydrocarbon. |
| *Benzaldehyde ? ... ..    |            | (Deposit which forms in Eucalyptus Oils.) |                    |
| *Piperitone ... ..        | Ketone.    |                                           |                    |

\* Constituents marked with an asterisk are the outcome of these investigations.

## Cineol (or Eucalyptol).

THIS constituent of Eucalyptus oils has the formula  $C_{10}H_{18}O$ ; specific gravity at  $15^{\circ}C.$  = 0.930; refractive index at  $20^{\circ}C.$  = 1.4584; boiling point  $176^{\circ}C.$ ; is optically inactive; crystallises at a low temperature, and melts at  $-1^{\circ}C.$  The oxygen atom is combined as oxide, and for this reason cineol does not react with either hydroxylamine or phenylhydrazine, nor does sodium act upon it in the ordinary way. Aldehydic, ketonic and alcoholic groupings are thus absent.

The name cineol was given to this oil constituent by Wallach and Brass [Ann. 225 (1884), 291], who first isolated it in a pure condition from the oil of the "Levant Wormseed," and characterised it as a definite chemical substance.

### QUALITATIVE METHODS FOR DETECTION.

The presence of cineol in Eucalyptus oils may be determined in several ways.

- (a) If the interior of a short test tube is moistened with the oil to be tested and the vapour of bromine passed into it, a crystalline addition product will be formed on the side of the tube, the crystals being very pronounced if the cineol is present in quantity, but indistinct if the reverse. A smear of the oil on a watch glass will answer just as well, and with practice, as little as 10 per cent. of cineol in Eucalyptus oils can be detected in this way.



- (b) The reaction with iodol, first described by Hirschsohn in 1893, can also be used for the detection of small amounts of cineol. The determination may be made by dissolving in a small quantity of the oil as much iodol as it will readily take up, gently heating if necessary. After a short time, if cineol be present, a crystalline compound will separate; this addition product consists of equal molecules of the components, and when recrystallised from alcohol or benzene melts at about  $112^{\circ}\text{C}$ .
- (c) A crystalline compound is formed with cineol, when dry hydrobromic acid gas is passed into a mixture of the well-cooled oil, or most suitable fraction, and an equal volume of petroleum ether; the crystals are filtered off and washed with petroleum ether. This hydrobromide melts at  $56\text{--}57^{\circ}\text{C}$ . and is readily decomposed into cineol and hydrobromic acid on the addition of water.
- (d) Cineol also combines with gaseous hydrochloric acid, with iodine, with  $\alpha$  and  $\beta$  naphthols, as well as with phosphoric and arsenic acids, and resorcinol.

#### THE PHOSPHORIC ACID COMPOUND.

Cineol forms a crystalline compound with phosphoric acid of specific gravity about 1.75, and this reaction is taken advantage of for its detection, as well as for its quantitative determination. It is not a satisfactory reagent, however, when only a small quantity of cineol is present in the oil, and even if containing as much as 20 or 30 per cent. it is often necessary to start the crystallisation by the addition of a minute crystal of cineol phosphate, prepared with a richer oil, and to use an ice cold bath. The combination between the cineol and the phosphoric acid is a very loose one, and even at room temperature the compound slowly changes with separation of cineol.

The reddish colouration given to Eucalyptus oils by phosphoric acid when cineol is tested by this method, is caused by the reaction between the acid and the sesquiterpene, a constituent which occurs in most Eucalyptus oils, sometimes in considerable quantity. In the oils of some species, however, it is present in very small amount, as for instance in those of the group to which *E. Australiana* belongs, so that in the oils of those species the colouration is usually somewhat indistinct. This is also the case when the oils have been rectified by direct distillation, as in this way the greater portion of the sesquiterpene, or other high-boiling constituent, mostly remains behind in the still, so that the colouration is not shown so distinctly as with the crude oils. The selective influence of cineol for phosphoric acid does not however take place, and the appearance of the pink colouration may thus be deceptive if considered as an indication of the end reaction.

It has been considered, and is often so stated, that the cineol and phosphoric acid enter into combination in molecular proportions; thus forming a solid compound with a definite composition. Helbing and Passmore (Pharmacological Record No. XXXV) describe this method for determining cineol, and assume the following equation:— $\text{C}_{10}\text{H}_{18}\text{O} + \text{H}_3\text{PO}_4 = \text{C}_{10}\text{H}_{18}\text{OH}_3\text{PO}_4$ , in which the cineol represents 61.1 per cent.

The question is, however, does the phosphoric acid enter into combination with the cineol in molecular proportions, or does it combine in the form in which it is used? If the latter, then the statement that the compound contains 61.1 per cent. of cineol is not correct.

We have endeavoured to solve this problem, with the result that our investigation shows that the phosphoric acid, specific gravity about 1.75, combines



with the cineol in its diluted state, so that correctly speaking no general formula can be given, as commercial phosphoric acid has not always the same concentration. From the results of this work, which was carried out with the oils of *E. cinerea*, *E. Smithii*, and *E. Morrisii*, it was found that the mean cineol content in the perfectly dry powdery compound was 59.47 per cent., while the phosphoric acid ( $\text{H}_3\text{PO}_4$ ) only represented 89.27 per cent., the difference being water. The  $\text{H}_3\text{PO}_4$  in the acid employed was 89.4 per cent. The theoretical mean for the cineol from the  $\text{H}_3\text{PO}_4$  found was 59.56 per cent., thus being in very fair agreement.

The results showed that 59.5 was approximately the amount of cineol in 100 parts of cineol-phosphate, and not 61.1 per cent., as was previously supposed.

#### QUANTITATIVE DETERMINATION OF CINEOL IN EUCALYPTUS OILS.

Although several methods for the quantitative determination of cineol have been employed, chiefly based on the reactions and combinations it forms with various reagents, yet, it must be admitted that none of them gives results absolutely correct, so that a successful method for determining accurately the amount of cineol in Eucalyptus oil, under all conditions, has yet to be discovered.

With present methods advantage is taken of the loose combinations cineol forms with phosphoric acid or arsenic acid of certain strengths, or by absorption with resorcinol. Difficulties, however, present themselves, particularly the instability of the compounds with the acids under atmospheric conditions. With resorcinol the trouble is that other substances present in Eucalyptus oils besides the cineol are also absorbed.

With the phosphoric acid or arsenic acid methods the result depends, to a certain extent, on the manipulation, as well as the method of procedure adopted, so that, for commercial purposes at any rate, some uniform method should be recognised, such process being carried out always in a similar manner.

To largely remedy this defect of the "personal equation" we have devised a Rapid Phosphoric Acid Method, using petroleum ether, as in this way both quantities and times are fixed and the results satisfactory. (In connection with this problem see "Perfumery and Essential Oil Record," August, 1919, p. 211. Bennett and Salomon.)

The quantitative determinations for cineol recorded in the first edition of this work (published 1902) were all carried out with the phosphoric acid method as employed at that time. It was then considered necessary for the sake of cineol phosphate to be repeatedly pressed between fresh paper until grease spots ceased to appear. This rigid method of procedure is now known to have given too low results, more particularly in a hot climate like that of Sydney, and it might therefore have been permissible to add a certain percentage to the figures there given. We have, however, in this edition retained the results as previously recorded, but have added the letters O.M. (meaning old method) to denote the particular process employed.

In other cases where the more recent application of the phosphoric acid method has been used those letters are omitted, or the process employed is noted. Recently the resorcinol method has been utilised to a considerable extent, but in all cases where this has been done, it is so stated; with several of the oils the necessary corrections have been made for the non-cineol substances absorbed, or for the alcohols present, and with a very large number the results obtained with the phosphoric acid method are also given for comparison.

**HYDROBROMIC ACID METHOD.**

This method for the quantitative determination of cineol is a complicated process, and not likely to become of general application; besides it has no advantage over more simple methods. Although the compound is formed in oils somewhat poor in cineol, and is thus sometimes useful for qualitative work, yet the process does not give a very stable product, and results are low.

**DISTILLATION METHOD.**

This method, which depends on the comparative ease with which cineol crystallises at a low temperature, has also been suggested for the quantitative determination of cineol (Helbing's Pharmacological Record, VIII, 1892.) It is not possible, however, to remove all the cineol in this way, so that the process is defective, and of little use for oils poor in cineol; thus it is not of general application.

**POTASSIUM PERMANGANATE METHOD.**

This method, proposed by F. D. Dodge (Journ. Industrial and Engineering Chemistry, Vol. IV, August, 1912), is based on the fact that, in the cold, cineol is practically unacted upon by a dilute solution of potassium permanganate, while many other constituents are oxidised into soluble compounds. The process has not come into general use and the results are not always reliable. (See also "Perfumery and Essential Oil Record," Nov., 1912, and Oct., 1913.)

**THE ARSENIC ACID METHOD.**

This method was proposed by J. L. Turner and R. C. Holmes in America in 1914. It depends on the fact that arsenic acid of about 85 per cent. strength combines with cineol to form a solid compound in the same way as does phosphoric acid. The method is now official in the United States Pharmacopœia, where the process is fully described and directions given for carrying it out.

It has been known for some time that cineol combines with arsenic acid in this way, and a patent was taken out in Germany in 1901, Ger. Pat. No. 132,606 (1901), and also in the United States of America, U.S. Patent No. 705,545 (1902), covering the production of cineol from this compound. The method was probably first applied for investigation purposes by Thoms and Molle for the separation of cineol from the oil of Bay Laurel. (Arch. der Pharm. 242, 1904, p. 172.)

We do not think that arsenic acid can claim superiority over phosphoric acid for the quantitative determination of cineol in Eucalyptus oils. We have not been successful in obtaining concordant results with the same oil when using the arsenic acid method quantitatively, and for that reason have ceased to use the process.

**THE RESORCINOL METHOD.**

This method for the quantitative estimation of cineol in Eucalyptus oils was first introduced by Schimmel and Co. in 1907 (semi-annual report for October). The principle is based on the fact that cineol forms an addition product with resorcinol, the compound being soluble in a 50 per cent. aqueous solution of that substance.

As first proposed the process was faulty, as several other substances which occur in the various Eucalyptus oils are absorbed at the same time as the cineol.

Later, Wiegand and Lehmann brought forward a modified process (Chemiker Zeitung 32, 1908, 109), in which the oil was first fractionated, the



portion which came over between 170–190° C., being used for the absorption, and the result calculated for the original oil. (See also in this connection C. F. Bennett, "Perfumery and Essential Oil Record," Oct., 1912.)

With the heavy cineol Eucalyptus oils of the *E. polybractea* class, in which only a very small portion distils below 170° C., this modified method may succeed in concentrating the cineol, but with the pinene-cineol oils in which a considerable fraction is obtained boiling below 170° C. a good deal of cineol comes over in that portion, and it does not seem possible, by direct distillation of oils of this class, to prevent much cineol distilling over with the pinene in this way.

With a large number of Eucalyptus oils in which cineol is only present in small amount and other constituents soluble in resorcinol not at all pronounced, the process acts very well, and cineol as low as 5 per cent. can be determined in this way. Such oils are those consisting largely of pinene, as *E. dextropinea*, *E. laevopinea*, &c., and many of the phellandrene-bearing oils, such as *E. oreades*, *E. Delegatensis*, *E. stellulata*, &c.

The method was also found useful for comparative purposes, as, for instance, in the investigation of the oils of *E. Smithii* from various forms of growth (Proc. Roy. Soc., N.S.W., Aug., 1915). Those results are also published in this work. The oil of this species contains a very small amount of substances other than cineol absorbable by resorcinol, and this is also the case with that of *E. polybractea* and a few others of the richer cineol class.

The resorcinol method may be considered a useful one for determining the cineol in a number of Eucalyptus oils, and may be satisfactorily employed for that purpose, but is more particularly applicable with those for which the phosphoric acid method is useless. Like all other known methods it is not of universal application, owing to the great diversity of constituents in Eucalyptus oils, and it thus becomes necessary to discriminate when choosing the method to be employed. The resorcinol process is also useful in assisting the investigation of undetermined Eucalyptus oils.

Unfortunately many constituents which occur in varying amounts in Eucalyptus oils are absorbed by 50 per cent. resorcinol, equally with cineol, and this is the case with the alcohols, as geraniol, terpineol, eudesmol, amyl, butyl, &c.; the aldehydes as aromadendral, citral, citronellal, butaldehyde, &c.; the lower esters as amyl-acetate, butyl-butyrate, &c.; piperitone and other bodies containing oxygen.

It is thus evident that the resorcinol method cannot be expected to give accurate results with all Eucalyptus oils, particularly those in which the constituents enumerated above occur in quantity, and it is difficult, if not impossible, with the oils of many Eucalyptus species to prepare a fraction in which the whole of the cineol is concentrated, and at the same time for it to be comparatively free from other absorbable constituents. If these are known, however, they can be separately determined, and allowed for, and in this way the cineol results might be made fairly accurate.

Illustrations of this procedure are given under *E. dives*, *E. piperita*, and other species in which the amount of piperitone in the fraction boiling below 190° C. was separately determined and allowed for.

As illustrating the difficulties in this connection the following analyses are given, and the four oils investigated are quite representative of the cineol Eucalyptus oils at present found on the market. The data have been obtained from the rectified oils distilling below 190° C., in order that the results with the rapid phosphoric acid and resorcinol methods might be compared, and the amount of absorbable constituents, other than cineol, indicated.



Ordinary constants for the crude oils employed are given, together with their cineol contents, calculated from the results obtained with the rectified oils. The alcoholic values, determined after acetylation, are calculated for  $C_{10}H_{18}O$ .

From the results here appended it is seen that the cineol in the oils of the *E. cneorifolia* and *E. Australiana* types cannot be satisfactorily determined quantitatively by the resorcinol method, although it might well be employed for the oils of the class to which *E. polybractea* and *E. Smithii* belong, and give results comparable with those obtained with phosphoric acid

*EUCALYPTUS POLYBRACTEA.*

Wyalong, N.S.W.

|                                              | Crude oil.     | Rectified portion boiling<br>below 190° C.<br>(91 per cent.) |
|----------------------------------------------|----------------|--------------------------------------------------------------|
| Specific gravity at 15° C. ... ..            | = 0.9201       | = 0.9194                                                     |
| Optical rotation $a_D$ ... ..                | + 1.8°         | + 1.9°                                                       |
| Refractive index at 20° C. ... ..            | = 1.4595       | = 1.4594                                                     |
| Cineol (rapid phosphoric acid method) ... .. | = 78 per cent. | = 86 per cent.                                               |
| Cineol (resorcinol method) ... ..            | = 82 per cent. | = 90 per cent.                                               |
| Absorption with $NaHSO_3$ ... ..             | .....          | = 2 per cent.                                                |
| Saponification number (1½ hours hot) ... ..  | .....          | = 4.06.                                                      |
| After acetylation (1½ hours hot) ... ..      | .....          | = 10.52.<br>= 1.8 per cent. free alcohol.                    |

By allowing for the absorbable constituents and the free alcohol the cineol was practically the same both by the phosphoric and resorcinol methods.

*EUCALYPTUS SMITHII.*

Hill Top, N.S.W.

|                                              | Crude oil.       | Rectified portion distilling<br>below 190° C.<br>(95 per cent.) |
|----------------------------------------------|------------------|-----------------------------------------------------------------|
| Specific gravity at 15° C. ... ..            | = 0.9292         | = 0.9213                                                        |
| Optical rotation $a_D$ ... ..                | + 4.0°           | + 3.7°                                                          |
| Refractive index at 20° C. ... ..            | = 1.4618         | = 1.4598                                                        |
| Cineol (rapid phosphoric acid method) ... .. | = 81 per cent.   | = 85 per cent.                                                  |
| Cineol (resorcinol method) ... ..            | = 85.5 per cent. | = 90 per cent.                                                  |
| Absorption with $NaHSO_3$ ... ..             | .....            | = 2 per cent.                                                   |
| Saponification number (1½ hours hot) ... ..  | .....            | = 5.4                                                           |
| After acetylation (1½ hours hot) ... ..      | .....            | = 11.08<br>= 1.58 per cent. free alcohol                        |

In this case, also, after allowing for the absorbable substances other than cineol, the results were practically the same by both methods.

*EUCALYPTUS AUSTRALIANA.*  
Nerrigundah, N.S.W.  
(1st Hour Oil. Commercial sample.)

|                                              | Crude oil.     | Rectified portion distilling<br>below 190° C.<br>(92 per cent.) |
|----------------------------------------------|----------------|-----------------------------------------------------------------|
| Specific gravity at 15° C. ... ..            | = 0.9198       | = 0.9190                                                        |
| Optical rotation $\alpha_D$ ... ..           | + 2.8°         | + 2.7°                                                          |
| Refractive index at 20° C. ... ..            | = 1.4609       | = 1.4602                                                        |
| Cineol (rapid phosphoric acid method) ... .. | = 72 per cent. | = 78 per cent.                                                  |
| Cineol (resorcinol method) ... ..            | = 84 per cent. | = 91 per cent.                                                  |
| Absorption with NaHSO <sub>3</sub> ... ..    | .....          | = 3 per cent.                                                   |
| Saponification number (1½ hours hot) ... ..  | .....          | = 2.97                                                          |
| After acetylation (1½ hours hot) ... ..      | .....          | = 24.88                                                         |
|                                              |                | = 6.05 percent. free alcohol.                                   |

The resorcinol method was thus shown not to be suitable for cineol determination in the oil of this species. The alcohols present were largely terpineol and geraniol.

*EUCALYPTUS CNEORIFOLIA* (a somewhat old sample).  
Kangaroo Island, South Australia.

|                                              | Crude oil.     | Rectified portion distilling<br>below 190° C.<br>(91 per cent.) |
|----------------------------------------------|----------------|-----------------------------------------------------------------|
| Specific gravity at 15° C. ... ..            | = 0.9304       | = 0.9198                                                        |
| Optical rotation $\alpha_D$ ... ..           | — 2.4°         | — 1.5°                                                          |
| Refractive index at 20° C. ... ..            | = 1.4677       | = 1.4637                                                        |
| Cineol (rapid phosphoric acid method) ... .. | = 62 per cent. | = 68 per cent.                                                  |
| Cineol (resorcinol method) ... ..            | = 83 per cent. | = 91 per cent.                                                  |
| Absorption with NaHSO <sub>3</sub> ... ..    | .....          | = 6 per cent.                                                   |
| Saponification number (1½ hours hot) ... ..  | .....          | = 9.55                                                          |
| After acetylation (1½ hours hot) ... ..      | .....          | = 20.05                                                         |
|                                              |                | = 2.9 per cent. free alcohol.                                   |

It is thus evident that the resorcinol method is neither suitable for the quantitative estimation of cineol in the oil of this species, nor in oils of this class, and numerous instances of this will be found recorded in this work, under the several species.

**THE PHOSPHORIC ACID METHOD.**

The phosphoric acid method for the determination of cineol in Eucalyptus oils was originally discovered by Mr. L. R. Scammell, of Adelaide, South Australia, in 1892, and was the outcome of an investigation on various samples of cheap oils then being placed on the market. The process was used by Messrs. Faulding & Co. for the manufacture of Eucalyptol, or cineol, which they shipped to England. In 1894 the process was patented by Mr. Scammell, as Faulding's



Process, in England, France, Germany, and America, as well as in the Australian colonies. With this method available it was possible to introduce a standardised oil containing a guaranteed quantity of cineol, and to this end Messrs. Faulding & Co. instructed their agent in England to call upon every retail chemist in London, in order to explain the phosphoric acid method for testing Eucalyptus oils.

This method is convenient, and with ordinary care can be carried out with fair success, particularly with Eucalyptus oils required to pass the official standards, in which much cineol is now demanded. Although the method does not indicate absolutely the actual amount of cineol present, yet, when undertaking the work for the first edition, we found it most useful for arranging the oils of the several members of the genus into groups, for the purpose of classification. Unfortunately the method is not very satisfactory, for quantitative purposes, when only a small amount of cineol is present, and it is necessary in such cases to fractionate the oils and determine the amount of cineol in the most suitable fraction. With the oils of many species the method cannot be employed, as the cineol is too small in amount.

The phosphoric acid method is official in the British Pharmacopœia and is there directed to be carried out in the following manner:—"When 10 millilitres of the oil are mixed with 4 to 5 millilitres of syrupy phosphoric acid in a vessel surrounded by a freezing mixture, and then pressed strongly in a piece of fine calico between folds of blotting paper, the pressed cake decomposed by warm water in a graduated vessel yields an oily layer which on cooling to  $15.5^{\circ}\text{C}$ . measures not less than 5.5 millilitres (presence of not less than 55 per cent. of cineol)."

#### A RAPID PHOSPHORIC ACID METHOD, USING PETROLEUM ETHER.

This method, which we now propose, works very well with most Eucalyptus oils containing 20 per cent. of cineol or over, is quickly carried out, and thus suitable for commercial analytical work. Eucalyptus oils which give a compound that cannot be satisfactorily pressed by the British Pharmacopœia method, may be readily determined in this way, and the decomposition of the cineol-phosphate by long pressing—particularly in hot countries—is prevented.

The richest cineol oils give the best results when they are first diluted with the addition of one-third the volume of freshly distilled pinene (turpentine) or the non-cineol bearing portion of the more pronounced phellandrene Eucalyptus oils. The method is recommended to be applied in the following manner:—

If a preliminary test indicates from 60 to 80 per cent. of cineol, the oil is diluted as directed above; if about 60 per cent. or below, it can be used directly. 10 c.c. of the oil to be determined are placed in a suitable vessel which is stood in a bath of ice and salt, and 4 c.c. of phosphoric acid are slowly added, a few drops at a time (3 c.c. if below about 30 per cent.), incorporating these between each addition.

The cineol-phosphate is then allowed to remain in the bath for fully five minutes, in order that the combination may be complete. A test tube containing 10 c.c. of petroleum ether, boiling below  $50^{\circ}\text{C}$ ., is placed in the bath and when quite cold is added to the cake of cineol phosphate and well incorporated with the mass, using a flat-ended rod for the purpose. The mixture is at once



transferred to a small Buchner funnel, 5 c.m. in diameter, upon which is placed a closely fitting filter paper. The non-combined portion is then rapidly sucked away by the aid of the filter pump. The thus dried cake is then transferred to a piece of fine calico, the calico folded over and the cake spread with a spatula to cover an area of about 6 c.m. by 8 c.m., finally folded into a pad, which is placed between several layers of absorbent paper and the whole strongly pressed for three minutes. The cake is then broken up with a spatula on a glazed tile or on glass, transferred to a measuring flask with graduated neck, decomposed with warm water, the cineol lifted into the neck of the flask, cooled, and when the separation is complete the volume measured. If the original oil were diluted a correction is, of course, necessary. We have obtained very concordant results with the same sample of *Eucalyptus* oil and now use the method constantly.

In order to test the range of accuracy with this method, using pure cineol, and mixtures of cineol and the phellandrene fraction of *Eucalyptus radiata* and *E. dives*, the following tabulated results were obtained. The cineol content in the mixtures employed had the following range, 80, 66.6, 60, 40, 33.3, and 20 per cent. The more satisfactory results were obtained when the mixtures richest in cineol were diluted. To secure good results the acid should be added slowly, the mixture made very cold, and the petroleum ether rendered quite cold before adding to the cake.

| Cineol percentage. | Percentage of cineol by the British Pharmacopœia method.<br>Half-hour pressing. |                                 | Percentage of cineol by the rapid phosphoric acid method, as described above. |
|--------------------|---------------------------------------------------------------------------------|---------------------------------|-------------------------------------------------------------------------------|
|                    | Undiluted.                                                                      | Diluted $\frac{1}{3}$ volume.   |                                                                               |
| 100 ... ..         | 90 to 92.<br>3 determinations.                                                  | 97 to 99.*<br>6 determinations. | 97 to 99† (diluted one-third).<br>4 determinations.                           |
| 80 ... ..          | 78 to 79.<br>4 determinations.                                                  | 77 to 78.<br>2 determinations.  | 77 to 79 (diluted one-third).<br>4 determinations.                            |
| 66.6 ... ..        | .....                                                                           | .....                           | 66 (not diluted).<br>2 determinations.                                        |
| 60 ... ..          | 56 to 58.<br>3 determinations.                                                  | .....                           | 57 to 59 (not diluted)<br>5 determinations.                                   |
| 40 ... ..          | Results not satisfactory.                                                       | .....                           | 38 to 40 (not diluted).<br>8 determinations.                                  |
| 33.3 ... ..        | .....                                                                           | .....                           | 33 (not diluted).<br>2 determinations.                                        |
| 20 ... ..          | .....                                                                           | .....                           | 18 to 20 (not diluted).<br>2 determinations.                                  |

\* The cineol remaining from these determinations had specific gravity at 15° = 0.929; rotation  $\alpha_D$  — 0.2°; refractive index at 20° = 1.4607.

† The cineol from these determinations had specific gravity at 15° = 0.929; rotation nil; refractive index at 20° = 1.4589.

A more perfect separation by the rapid method is thus shown,

## SUMMARY OF METHODS.

The foregoing may be summarised as follows :—

1. That an accurate method for determining the amount of cineol in Eucalyptus oils under all conditions has yet to be discovered.
2. That no one present method is applicable in all cases.
3. That arsenic acid is less advantageous for the purpose than phosphoric acid.
4. That the use of petroleum ether in connection with phosphoric acid is an advantage if the process be carried out in the manner directed.
5. That the richest cineol Eucalyptus oils should be diluted with non-cineol containing terpenes, corrections being made for the dilution.
6. That the resorcinol method is only applicable with certain oils, such as those containing cineol in the greatest amount, or those in which it occurs in too small quantity to be determined with phosphoric acid. Constituents absorbable by resorcinol, other than cineol, are too abundant in Eucalyptus oils for this method to be of general application, although it has certain advantages for experimental work.
7. The process recommended for the purpose, in Australia particularly, is the rapid phosphoric acid method, using petroleum ether in order to remove the non-cineol bodies before pressing.

## Geraniol and its Acetic Acid Ester Occurring in Eucalyptus Oils.

THE alcohol geraniol and its acetic acid ester are frequently occurring constituents in Australian plants, and in the oils of no less than three species does geranyl-acetate occur to the extent of 60 per cent. or over.

The coniferous tree *Callitris Tasmanica*, the "Oyster Bay Pine" of Tasmania, yields an oil of this character (Research on the Pines of Australia, Baker and Smith, Technical Education Series, N.S.W., No. 16, page 240), while the others belong to the Myrtaceæ. One of these is *Darwinia fascicularis*, a shrub growing around the shores of Port Jackson, New South Wales (Proc. Roy. Soc., N.S.W., December, 1899), while the other, *Eucalyptus Macarthuri*, is a fine foliaceous tree which grows plentifully in the Wingello and neighbouring districts of New South Wales (Proc. Roy. Soc., N.S.W., November, 1900). In lesser amounts this ester occurs in the oils of numerous species of Eucalyptus.

Geranyl-acetate is also the chief ester in the oils of the Angophoras, a genus closely related to Eucalyptus, and perhaps the older. If this is so then most likely the ester passed into Eucalyptus through Angophora, and as it occurs also in the oils of many of the "Peppermints" it probably runs through the whole genus Eucalyptus, although in some of the oils the amount is very small.

*Eucalyptus Macarthuri*, similarly with other species of Eucalyptus, shows a comparative constancy in oil products. That this is so has been well demonstrated from the results of much work carried out with this species during recent years. We have recorded some of this data under the species in this publication.



One distinguishing feature with the oil of *Eucalyptus Macarthuri* is the presence of crystallised eudesmol, a substance absent in the oils of both *Darwinia* and *Callitris*.

The following constants are those for a fair sample of the crude oil of *Eucalyptus Macarthuri*:—

|                                                         |     |     |     |     |                   |
|---------------------------------------------------------|-----|-----|-----|-----|-------------------|
| Specific gravity at 15° C.                              | ... | ... | ... | ... | = 0.9174.         |
| Optical rotation $a_D$                                  | ... | ... | ... | ... | + 0.69°.          |
| Original ester                                          | ... | ... | ... | ... | = 68.4 per cent.  |
| Ester after acetylating (cold saponification)           | ... | ... | ... | ... | = 81.02 per cent. |
| Refractive index at 20° C.                              | ... | ... | ... | ... | = 1.4721.         |
| Soluble in $1\frac{1}{4}$ volumes 70 per cent. alcohol. |     |     |     |     |                   |

In the course of these researches it was found that the acetic acid ester of geraniol was entirely saponified in the cold by two hours' contact with alcoholic potash, the reaction being of considerable quantitative value. In both the bark and leaf oils of *Eucalyptus Macarthuri* the naturally formed ester varies between 60 and 77 per cent., but this variation represents largely the oscillation between the ester and the free geraniol, consequently when the free alcohol is pronounced the ester is less, and when the ester is at a maximum the minimum amount of free geraniol is present. In no instance has less than 60 per cent. of geranyl-acetate been found in the oil of this species of *Eucalyptus*, although it sometimes reaches as high as 77 per cent. In one sample containing 74.9 per cent. ester, only 6 per cent. of free geraniol was present. Another sample gave 65.8 per cent. ester, and 11.5 per cent. free alcohol. Other determinations were in agreement, and in all the analyses we have so far been able to make with the oil of this *Eucalypt* the ratio  $\frac{\text{combined geraniol}}{\text{total geraniol}}$  has ranged between 80–100 and 90–100.

With both the New South Wales and Tasmanian samples of the oil of *Callitris Tasmanica*, the  $\frac{\text{combined geraniol}}{\text{total geraniol}}$  was 78–100.

It has been found by Charabot and Hébert in their experiments "on the mechanism of esterification in plants," that the maximum ester content obtained with geraniol and acetic acid, by their methods of working, was reached when the  $\frac{\text{combined geraniol}}{\text{total geraniol}}$  equalled 67–100; but as shown above, this naturally formed ester in the oils of these two Australian plants does not fall below 78–100; and occasionally reaches 90–100. It is thus evident that the method whereby this large amount of geranyl-acetate is formed naturally, is not yet known.

The abnormal leaves which spring from the stumps of the felled trees of *E. Macarthuri* not only give a greater yield of oil, but the oil itself also contains a greater percentage of ester than does that from old leaves. A sample, distilled from such, collected at Paddy's River, New South Wales, in March, contained 77.5 per cent. of ester saponified in the cold with two hours' contact.

The oil from seedlings has also a high ester content, exceeding, in some cases, 70 per cent., while in that from the very early shoots the ester was 75 per cent.

It is perhaps worthy of note that a predominance of this ester should be found in the oil from the youngest material, and that the trend of the mechanism of ester formation should show such activity so early in the life history of the plant.

It is characteristic, however, of the *Eucalypts* generally, for the perfumery products peculiar to the species to be formed very early in the plant, and in the very young seedling leaves the chief oil constituent of the species is in evidence.

The time of year also appears to have some influence on the ester formation in the oil of *E. Macarthuri*, but to a less extent than the age of the leaf material, so that the oil distilled commercially from cultivated plants of this species should show a high ester content, perhaps, as an average, not less than 5 per cent. in excess of that found in the leaf oil collected from old trees growing naturally.



Free acetic acid always occurs in the oils of this species, and phenols are also present, so that the crude oil is usually red in colour, particularly if the digester and worm of the still had been constructed of iron.

**Determination of the Ester.**—The ester was determined by heating on the water bath, under reflex condenser, with 20 c.c. semi-normal alcoholic potash, and titrating with semi-normal sulphuric acid in the usual way. The following figures give the results obtained with an oil containing the least amount of ester we have so far experienced with the oil of this species :—

2.9725 gram. required 0.5124 gram. KOH  $\therefore$  S.N. = 172.38.

3.0125        „        „        0.5194        „        „        = 172.40.

As the ester was wholly geranyl-acetate, with a molecular weight 196, the percentage of ester was 60.34.

To determine the free acid a portion of the oil was agitated with dilute aqueous sodium hydrate, washed and dried.

1.945 gram. neutral oil required 0.3332 gram. KOH  $\therefore$  S.N. = 171.3.

The result from this is 59.95 per cent. of ester, and free acid showing a saponification number 1.1, or an ester value of 0.39 per cent. It is not permissible to attempt the determination of the free acid by alcoholic potash in the usual way, as the saponification of the ester commences at once, and with two hours' contact the whole is saponified. This is shown by the following result obtained with the neutral oil as above.

In this case only one and a half hours elapsed after the addition of the alcoholic potash before titration.

1.65 gram. required 0.2828 gram. potash  $\therefore$  S.N. = 171.4.

This result is equal to 59.99 per cent., and shows that the ester was entirely saponified during that time.

**The Free Alcohol.**—The acetylation of the free alcohol in the above sample was carried out in the usual manner, by boiling for one hour and a half with acetic anhydride and anhydrous sodium acetate, adding water, and finally washing until the oil was neutral. By cold saponification with two hours' contact :—

1.5066 gram. required 0.3164 gram. KOH  $\therefore$  S.N. = 210.

This gives an ester value of 73.5, calculated as geranyl-acetate. As 59.99 per cent. of ester was originally present, this represents 13.51 per cent. of ester formed by the free geraniol present. The free geraniol in the oil was thus 10.6 per cent. and the ratio  $\frac{\text{combined geraniol}}{\text{total geraniol}} = 81-100$ .

Corresponding duplicate determinations were obtained in each case.

It thus appears that other esters found in Eucalyptus oils were practically absent in that of this species, and all our results support this conclusion. At any rate, they can only occur in very small quantity at any time.

**The Geraniol.**—The pure alcohol was prepared by saponifying the oil in the cold and then combining it with dry calcium chloride. The compound  $C_{10}H_{18}O$ ,  $CaCl_2$  was then ground up with benzene, freed from liquid by means of the pump, and finally washed with dry ether. It was then decomposed by water, the oil washed, and finally steam-distilled.

The resulting product was colourless, had a rose-like odour, was inactive, had specific gravity 0.885, and boiled at  $224-225^\circ C$ . (uncorr.).

A portion was oxidised by using potassium bichromate and sulphuric acid in the usual way and the product combined with sodium bisulphite, the crystalline mass purified and decomposed. The separated oil had an odour of citral and formed the citryl- $\beta$ -naphthocinchoninic acid melting at  $199-200^\circ C$ .

**The Acid of the Ester.**—The aqueous portions remaining from the saponifications were mixed together, the whole evaporated almost to dryness, and distilled with dilute sulphuric acid, adding fresh quantities of water until the

volatile acid had all come over. A portion of the distillate was exactly neutralised with barium hydrate solution, evaporated to dryness, heated in air oven to render the salt anhydrous, and finally igniting with sulphuric acid. 0.828 grams gave 0.754 grams barium sulphate = 91.06 per cent. A second determination gave corresponding results.

Barium acetate theoretically gives 91.37 per cent. barium sulphate, a result which indicates that a very small amount of another volatile acid than acetic was present in the oil as ester. When the barium salt was first decomposed the odour suggested valeric acid as well as acetic, and as valeric acid ester is a common constituent in Eucalyptus oils, it may thus occur in traces in the oil of *E. Macarthuri*.

The remainder of the distillate was exactly neutralised with sodium hydrate and evaporated to crystallising; well-formed crystals of sodium acetate were thus obtained.

## The Terpeneols of Eucalyptus Oils.

IN a paper on *Eucalyptus Australiana* and its essential oil, read by us before the Royal Society of New South Wales, December, 1915, it was shown that a considerable quantity of a high-boiling aromatic alcohol was present in the oil of this species, and that it was concentrated to a considerable extent in that portion of the oil which came over during the second and third hours of distillation, and analysis showed that between 30 and 40 per cent. of the third hour oil consisted of this alcohol. Considerable work has now been undertaken with this alcohol, and it has been isolated from the oils of several species, with the result that it is now shown to be terpeneol, and to exist in Eucalyptus oils in both the dextro- and lævo-rotatory modifications.

Voiry had shown in 1888 that terpeneol and its esters occurred in the oil of *E. globulus* (Compt. Rend. 106, 1888, 1419).

Dextro-rotatory terpeneol has now been isolated from the oils of some of the earlier members of the genus, viz., *E. diversicolor* and *E. carnea*; and the lævo-rotatory terpeneol from the oils of *E. Australiana* and *E. phellandra*. The terpeneol isolated from the oil of the latter species had a higher lævo-rotation than had that of the former. It may be supposed, therefore, that terpeneol—similarly with geraniol—runs through the whole genus, occurring in larger or smaller amounts in the oils of the several species, sometimes in the free condition, and as terpinyl-acetate or terpinyl-butyrate.

The alcohol has so far been found to occur in the liquid form, but was crystallised when subjected to considerable cold for a sufficiently long period. The solid form when purified melted at near 35° C., and had the characteristic lilac odour of terpeneol.

In the first edition of this work the oil of *E. phellandra* (known at that time as a form of *E. amygdalina*), although containing only about 30–40 per cent. of cineol, was shown to be exceedingly soluble in 70 per cent. alcohol. This peculiarity for an oil in which phellandrene occurs in some quantity is now known to be chiefly due to the presence of the terpeneol. The species *E. Australiana* was not discovered until many years later.

When the crude oil of either *E. Australiana* or *E. phellandra* was treated with phosphoric acid on a watch glass and the cake of cineol phosphate allowed to remain in the open for two or three days, crystals eventually appeared in the



otherwise liquefied mass. These crystals were shown to be terpin hydrate, and had evidently been formed by the action of the phosphoric acid on the terpineol.

When the crude oil of *E. Australiana* was determined quantitatively for cineol, and the cake of cineol-phosphate decomposed in the ordinary way, crystals often occurred in the separated cineol. They were sometimes present in such quantity as to render the junction of the liquids indistinct and correct reading difficult. These crystals were also found to be terpin hydrate, and had evidently been formed by the action of the phosphoric acid on the terpinol. Not being soluble in the petroleum ether, the crystals remained with the cineol phosphate.

H. J. Prins (Chem. Weekblad, 1917, 14, pp. 630-631) has shown that a good yield of terpin hydrate can be obtained by agitating terpineol with 80 per cent. phosphoric acid at 30° C.

This reaction with the oils of *E. Australiana* and *E. phellandra* is apparently one distinguishing feature between them and other Eucalyptus oils on the market, while the presence of the phellandrene distinguishes the oil of the latter species from that of the former.

#### (a) TERPINEOL FROM THE OIL OF *E. AUSTRALIANA*.

This was isolated from the "second hour" oil of *E. Australiana*, distilled for us by Mr. Gough, of Youri, New South Wales, in November, 1919. The crude oil had the following characters:—Specific gravity at 15° C. = 0.9081; rotation  $a_D$  — 2.0° C.; refractive index at 20° = 1.4704, and was soluble in 1½ volumes 70 per cent. alcohol. The saponification number for the esters, by heating 1½ hours, was 5.2; after acetylation it was 76.9 by heating, and 24.5 in the cold with two hours' contact. The cineol was determined by both the resorcinol and the rapid phosphoric acid methods in the portion boiling below 190°; when calculated for the original oil the result was 42 per cent. by resorcinol, and 25 per cent. by phosphoric acid.

4,000 c.c. of the oil were then distilled, when 65 per cent. came over below 190° C. This fraction and the portion boiling above 190° gave the following results:—

|                                                                    | Below 190° C. | Above 190° C. |
|--------------------------------------------------------------------|---------------|---------------|
| Specific gravity at 15° C. ... ..                                  | 0.8997        | 0.9260        |
| Rotation $a_D$ ... ..                                              | — 1.95°       | — 1.4°        |
| Refractive index at 20° C. ... ..                                  | 1.4650        | 1.4770        |
| Solubility in 70 per cent. alcohol ... ..                          | 1½ volumes.   | 1 volume.     |
| Cineol by phosphoric acid ... ..                                   | 38 per cent.  | .....         |
| Cineol by resorcinol ... ..                                        | 65 per cent.  | .....         |
| Saponification number (hot 1½ hours) ... ..                        | 2.7           | 9.6           |
| After acetylation, saponification number in cold, 2 hours' contact | 13.3          | 33.9          |
| " " " " hot, 1½ hours                                              | 41.8          | 132.7         |

By repeated fractionation of the portion boiling above 190° C. at 10 millimetres pressure, the following fractions were finally obtained (temperatures uncorrected):—

Boiling between 63 and 99° C., amount was 584 c.c.  
 " " 100 and 101° C., " " 300 c.c.  
 " " 101 and 110° C., " " 130 c.c.



The lower boiling fraction and the residue were discarded. The second fraction, 100–101° C. at 10 millimetres, gave the following results:—

|                            |        |                       |
|----------------------------|--------|-----------------------|
| Boiling point (766 mm.)    | ... .. | = 218–220° C. (corr.) |
| Specific gravity at 15° C. | ... .. | = 0.9359.             |
| Rotation $a_D$             | ... .. | — 5.0° C.             |
| Refractive index at 20° C. | ... .. | = 1.4816.             |
| Nitrosochloride, melted at | ... .. | 113° C.               |
| Phenylurethane, melted at  | ... .. | 112° C.               |

Both the nitrosochloride and the urethane were readily formed and in good quantity. These results indicate that the alcohol was terpineol and that the lævo-rotatory modification predominated to a small extent in the oil of this species.

The portion boiling between 101–110° C. was again fractionated at 10 millimetres, when 30 c.c. were obtained boiling between 108–110° C. This fraction had a distinct odour of geraniol. The specific gravity at 15° = 0.9316; rotation  $a_D$  — 1.5°; refractive index at 20° = 1.4841, and yielded a good amount of a urethane, melting at 112°. It is thus evident that a considerable amount of terpineol was also present in this portion. That it also contained geraniol was shown by the formation of citral on oxidation.

That geraniol is a common constituent in the oil of *E. Australiana* is also suggested from the frequent presence of citral in the natural oil, and we have isolated this aldehyde in a pure condition from the oil of this species distilled from material growing in the Burruga district of New South Wales.

Terpineol was also prepared from the second and third hour oils of this species, distilled from material growing at Nerrigundah, New South Wales. 500 c.c. boiling above 190° C. were repeatedly fractionated at 10 millimetres pressure, the following fractions being eventually obtained (temperatures uncorrected):—

|                 |                |            |          |
|-----------------|----------------|------------|----------|
| Boiling between | 70 and 99° C., | amount was | 180 c.c. |
| „ „             | 99 „ 101° C.,  | „ „        | 144 c.c. |
| „ „             | 101 „ 104° C., | „ „        | 5 c.c.   |
| „ „             | 105 „ 109° C., | „ „        | 30 c.c.  |
| „ „             | 110 „ 115° C., | „ „        | 40 c.c.  |

The fraction 99–101° C. at 10 millimetres had:—

|                            |        |           |
|----------------------------|--------|-----------|
| Specific gravity at 15° C. | ... .. | = 0.9362. |
| Rotation $a_D$             | ... .. | — 3.8°    |
| Refractive index at 20° C. | ... .. | = 1.4816. |
| Nitrosochloride melted at  | ... .. | 113°      |
| Nitrolpiperidine           | „ „    | 159–160°  |
| Phenylurethane             | „ „    | 112°.     |

When shaken with 5 per cent. sulphuric acid a good yield of terpin hydrate was eventually obtained.

The fractions 101–104° and 105–109° gave results agreeing with those of the first sample, and geraniol was readily detected in the higher-boiling fraction.

The terpineol from the Nerrigundah oil was thus in agreement with that from the Youri material, although showing a slightly less lævo-rotation. There was, however, a difference of four years in the dates of distillation of the two samples. This species is probably the best of all the Eucalypts from which to distil an oil containing the maximum amount of terpineol,

(b) TERPINEOL FROM THE OIL OF *E. PHELLANDRA*.

The "second hour" oil of this species was distilled for us by Messrs. Gillard Gordon, Ltd., at Braidwood, New South Wales, in November, 1919. It had the following characters:—Specific gravity at 15° C. = 0.9035; rotation  $a_D$  — 15.75°; refractive index at 20° C. = 1.4708; soluble in 1½ volumes 70 per cent. alcohol, and contained a considerable amount of phellandrene. The cineol, determined by the resorcinol method in the portion distilling below 190° C. was 52 per cent. when calculated for the crude oil. By the phosphoric acid method the result was 30 per cent. The saponification number for the esters was 10.3; after acetylation it was 57 by heating and 25.3 in the cold with two hours' contact.

4,000 c.c. were distilled, when 80 per cent. came over below 190° C. This fraction, and the portion boiling above that temperature, gave the following results:—

|                                           | Below 190° C. | Above 190° C. |
|-------------------------------------------|---------------|---------------|
| Specific gravity at 15° C. ... ..         | 0.8973        | 0.9352        |
| Rotation $a_D$ ... ..                     | — 16.0°       | — 6.0°        |
| Refractive index at 20° ... ..            | 1.4670        | 1.4836        |
| Solubility in 70 per cent. alcohol ... .. | 10 volumes    | 1 volume.     |
| Cineol by resorcinol ... ..               | 62 per cent.  | .....         |
| „ by phosphoric acid ... ..               | 33 per cent.  | .....         |
| Saponification number, hot ... ..         | 39.3          | 105.7         |
| „ „ cold ... ..                           | 18.4          | 45.9          |

By repeated fractionation of the portion boiling above 190° at 10 millimetres, 67 c.c. were obtained boiling at 100–101° C. (uncorr.). This had the following characters:—

Specific gravity at 15° C. ... .. = 0.9382.  
 Rotation  $a_D$  ... .. — 14.25°  
 Refractive index at 20° C. ... .. = 1.4817.  
 Phenylurethane melted at ... .. 112° C.

When shaken with 5 per cent. sulphuric acid a good yield of terpin hydrate was eventually obtained.

The terpineol in the oil of *E. phellandra* is thus shown to have a higher lævo-rotation than has that in the oil of *E. Australiana*.

(c) TERPINEOL FROM THE OIL OF *E. CARNEA*.

The oil of *E. carnea* had a high saponification number, and an attempt was made to determine the alcohol of the ester. The oil was saponified in the ordinary way, afterwards rectified, and the fraction boiling below 190° C. removed. The higher boiling portion was repeatedly rectified under reduced pressure, when a fraction distilling at 100–103° C. at 10 millimetres was eventually obtained. This had the following characters:—

Specific gravity at 15° C. ... .. = 0.930.  
 Rotation  $a_D$  ... .. + 60.1°  
 Refractive index at 20° ... .. = 1.4840.  
 Phenylurethane melted at ... .. 110° C.

When repeatedly shaken with 5 per cent. sulphuric acid, terpin hydrate was formed in some quantity. The terpineol in the oil of this species was thus shown to have a considerable dextro-rotation. The ester was chiefly terpinyl-acetate.



(d) TERPINEOL FROM THE OIL OF *E. DIVERSICOLOR*.

The saponification number for the original oil of this species was even higher than for that of *E. carnea*.

When rectified, 32 per cent. remained, boiling above 190° C. This portion had saponification number 129.7 by heating, and 34 in the cold with two hours' contact. It was then saponified in the usual way and the volatile acids separated and determined, the result being 86.9 per cent. barium-acetate and 13.1 per cent. barium-butyrate. The saponified oil was subjected to repeated distillation under reduced pressure until a fraction was obtained boiling at 99–100° C. at 10 millimetres. This had :—

|                                |        |           |
|--------------------------------|--------|-----------|
| Specific gravity at 15° C. ... | ... .. | = 0.940.  |
| Rotation $a_D$ ...             | ... .. | + 21.5°   |
| Refractive index at 20° ...    | ... .. | = 1.4831. |
| Phenylurethane melted at ...   | ... .. | 111° C.   |

It eventually gave a good yield of terpin hydrate when repeatedly shaken with 5 per cent. sulphuric acid.

The terpineol in the oil of this species was apparently combined with both acetic and butyric acids, but chiefly with the former. It may be assumed, therefore, that terpinyl-acetate is a constant constituent in the oils of the earlier members of the genus, and that the alcohol is highly dextro-rotatory. In the oils of the more recent groups the predominant terpineol appears to be mostly lævo-rotatory.

## Piperitol, the corresponding Alcohol to Piperitone.

THIS secondary alcohol occurs in the oils of the "Peppermint" group of Eucalypts, and although several members of this group give an oil containing only a comparatively small amount of piperitone (the peppermint ketone of Eucalyptus oils), yet a fair quantity of an alcohol—other than terpineol or geraniol—is present. This investigation showed this alcohol to be the corresponding one to piperitone, and is, therefore, named piperitol. It is an unsaturated alcohol.

Although it occurs naturally in a number of these oils, yet it has not, so far, been possible to form it by the reduction of the ketone, the reduction product, with sodium amalgam particularly, consisting of a solid dimolecular ketone of quite a definite character. (See also the article on piperitone in this work.)

Experience had shown us that one of the best oils for the preparation of this alcohol was that derived from *E. radiata*, and for this purpose material for distillation was obtained from Hill Top, New South Wales, in November, 1919. The yield of oil was 2.9 per cent. The oil of this Eucalypt consists very largely of phellandrene, and the leaves have the phellandrene venation particularly well-defined.

That ketonic and alcoholic bodies were only present in small amount is indicated from the specific gravity of the crude oil, this being only 0.8643 at 15° C. It was thus fortunate that the yield was so good, particularly as it was necessary to employ a considerable quantity of oil in order to prepare sufficient alcohol for investigation.



The crude oil was first distilled and the portion which came over below  $185^{\circ}\text{C}$ . removed. The remainder was repeatedly distilled under reduced pressure until finally a fraction boiling at  $100\text{--}103^{\circ}\text{C}$ ., at 10 millimetres was obtained. This had specific gravity at  $15^{\circ}\text{C}$ . =  $0.9326$ ; rotation  $a_D - 28.7^{\circ}$ ; refractive index at  $20^{\circ} = 1.4780$ .

As this fraction contained piperitone, it was removed by agitating with a solution of normal sodium sulphite; the ketone thus recovered in a pure condition, represented 17 per cent. of the fraction. It had all the characters of piperitone and on reduction with sodium amalgam in alcoholic solution gave the solid dimolecular ketone melting at  $149\text{--}150^{\circ}\text{C}$ .

The unabsorbed portion was again refractionated, when an oil boiling at  $95\text{--}96^{\circ}\text{C}$ . at 10 millimetres was obtained. This had:—

Specific gravity at  $22^{\circ}\text{C}$ . ... .. =  $0.9230$ .

Rotation  $a_D$  ... .. —  $34.1^{\circ}$

Refractive index at  $22^{\circ}\text{C}$ . ... .. =  $1.4760$ .

The molecular refraction calculated for a  $\text{C}_{10}\text{H}_{18}\text{O}$  alcohol with one double bond is  $47.14$ ; found  $47.04$ .

It is thus apparent that the lævo-rotation of the alcohol was—after distillation—greater than that of the corresponding ketone, but this may be partly due to the lowering of the optical rotation of piperitone under repeated distillation.

A portion of the alcohol was oxidised in the cold by the potassium bichromate method; when the reaction was complete the product was steam-distilled, the oil separated and agitated with a solution of neutral sodium sulphite in the cold, until practically the whole was absorbed. The regenerated product had all the characters of piperitone, and gave the solid dimolecular ketone on reduction with sodium amalgam. The piperitone thus formed had specific gravity at  $15^{\circ}\text{C}$ . =  $0.9390$ ; rotation  $a_D - 24.0^{\circ}$ ; and refractive index at  $20^{\circ} = 1.4832$ .

## Eudesmol, the Bicyclic Sesquiterpene Alcohol of Eucalyptus Oils.

CRYSTALLISED eudesmol was first discovered by us in the oil of *Eucalyptus piperita*, and announced in a paper read before the Royal Society of New South Wales in August, 1897. Later, further work upon this substance was submitted to the same society, by one of us, in a paper read August, 1899. The name eudesmol was derived from Eudesmia, which had been applied to the genus by Robert Brown.

When first isolated, eudesmol was thought to be an oxide related somewhat in constitution to cineol, but from the work carried out later by Semmler and E. Tobias (Ber. 46, 1913, 2026); and Semmler and F. Risse (Ber. 46, 1913, 2303); it was shown to be a bicyclic sesquiterpene alcohol, and to contain two rings and one double bond. The reaction with bromine in chloroform solution also shows it to be unsaturated.

During the last twenty years we have obtained much information concerning eudesmol and its peculiarities, and have isolated this interesting substance from the oils of numerous species of Eucalyptus.

There appears to be little doubt but that eudesmol occurs in Eucalyptus oils in both the liquid and crystallised conditions, although the line of demarcation separating these is evidently slight. It also appears that liquid eudesmol is the more stable form, because in nearly every case the tendency has been for the

purified crystallised eudesmol to slowly change its character, until eventually it forms a thick liquid mass, and with one exception all our samples have remained in this condition after settling down. Although this tendency of the separated crystallised eudesmol to revert to the semi-liquid form is so pronounced, yet under some conditions—which at present are not clear—this change has not taken place, and we have in our possession one sample distilled from the oil of

PLATE LXXXV.



ILLUSTRATING THE UNSTABLE NATURE OF EUDESMOL .  
FROM EUCALYPTUS OILS, IN THREE STAGES.

(For description see page 376.)

*E. camphora* twenty years ago, and thus separated in the crude condition, which has remained in the crystallised form all that time. In other cases eudesmol prepared from the oil of this species has liquefied after a few months. We also possess one sample of eudesmol separated from the oil of *E. Macarthuri*, which has remained in the crystallised condition for two years, and at present shows but little signs of alteration, whilst other specimens from the oil of this species, distilled at varying times of the year, have liquefied after a few months, although they had been prepared in exactly the same manner. As shown later it is possible to partly change this liquefied eudesmol back to the crystallised form.

Under natural conditions crystallised eudesmol appears to occur more frequently, and in greater abundance, in the oils of species belonging to the more recent groups in the evolutionary sequence of the genus, as the "Peppermints,"

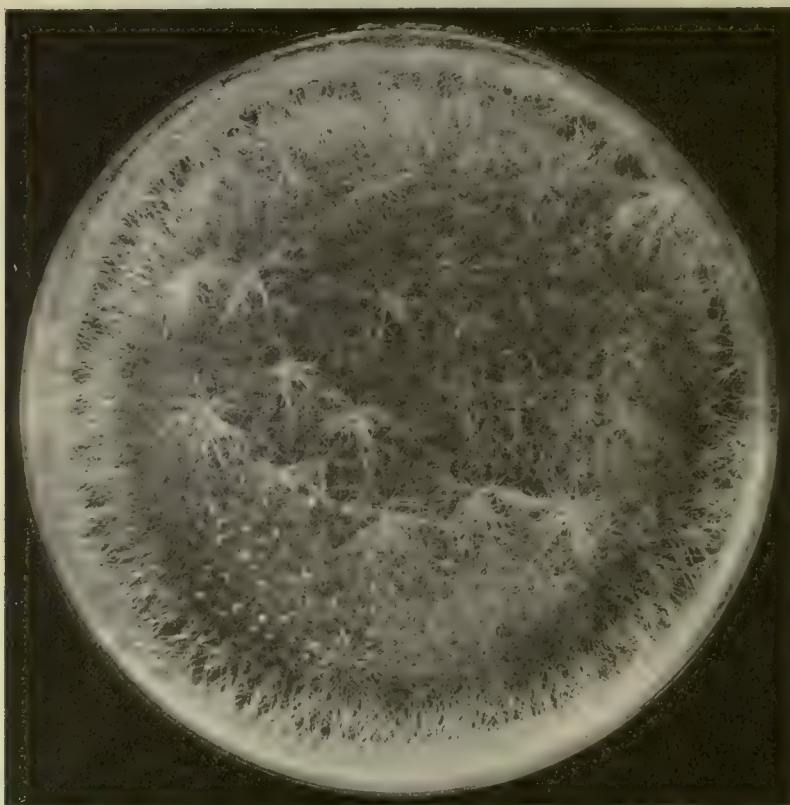


"Ashes," "Stringybarks," and some of the "Gums," whilst the liquid modification is more pronounced in those members belonging to the earlier groups, *E. eximia* for instance. It is also worthy of record that, so far, eudesmol has not been found to occur in the oils of species belonging to the typical "Box" group, *E. hemiphloia*, *E. Woollsiana*, &c., and with the exception of two species (*E. elæophora* and *E. stricta*) not in those of any species which contain one or more members of the cyclic aromatic aldehydes.

Plate LXXXV (page 375) illustrates very well the three different stages which may take place in the physical condition of eudesmol.

Originally the vessel was three parts full of pure crystallised eudesmol, melting at  $79-80^{\circ}$  C., which had been prepared from the oil of *Eucalyptus camphora*. After standing a few months the crystallised eudesmol had changed to the liquid condition, and had settled down to the layer shown at the bottom of the bottle. Some months after the formation of this condition, crystals began to grow from the thick liquid mass, and continued to increase until finally the whole assumed the appearance shown in the photograph. No further change

PLATE LXXXVI.



Eudesmol, recovered from the second stage, or liquid condition, into which the original crystallised eudesmol had passed on keeping.

has apparently taken place during the last seven years. The crystals of the third stage which thus appear quite stable, are hair-like in character, quite flexible, semi-transparent, but do not polarise at all well, and in many cases exceed one inch in length. They melted at  $79-80^{\circ}$  and thus at the same temperature as the original eudesmol. Under the microscope the crystals are



seen to be built up by the accumulation of longitudinal filaments, and when crushed can be separated into their component parts, thus showing how loosely they are combined. This is the only instance in which crystals of this character have formed naturally after the eudesmol had liquefied.

As previously mentioned, this liquid eudesmol can be changed to the crystallised condition, and this result is well shown by the accompanying illustration. The crystals depicted were regenerated from the wholly liquefied form of eudesmol originally prepared from the oil of *E. Macarthuri*.

The liquefied eudesmol was dissolved in ether, and the resinous acid portion, which had formed during the alteration, shaken out by aqueous potassium hydrate. The amount of acid substances thus removed was equal to 8 per cent. The ether was then evaporated from the liquid eudesmol, which at this stage showed no signs of crystallisation, and the residue sublimed on the water bath. A considerable portion was thus obtained in the crystallised condition, as depicted in the illustration. Under the microscope these crystals were seen to be identical with those formed naturally, and although less stout, to have been built up in a similar manner.

Unlike the originally crystallised eudesmol, these sublimed composite needles did not polarise at all well, but if melted, and again allowed to crystallise, they showed the same peculiarities of crystallisation and polarisation as in the case of the original eudesmol under similar conditions. Radiated masses of crystals in all cases gave well defined dark crosses similar to those shown by uniaxial crystals when observed under crossed nicol prisms.

The melting point of the sublimed crystals, derived from the liquid form, was some degrees lower than that of the original eudesmol; but in this respect there was little uniformity, as those which sublimed at the top of the covering dish, or furthest from the subliming material, melted at 74–76° C., while those formed nearest to it melted at 65–72° C. The slight amount of impurity present in the sublimed crystals was thus sufficient to lower their melting point, because when the whole was purified by recrystallising from alcohol, the melting point was that of the original eudesmol, 79–80° C.

The liquid residue, separated from the acid bodies as described above, was therefore shown to be eudesmol, and this conclusion was also supported by the formation of the acetate in almost theoretical amount on acetylation, as well as by the character and behaviour of the crystals formed by sublimation, and their microscopic appearance.

That eudesmol occurs naturally in the liquid form in some Eucalyptus oils is perhaps best shown with that of *E. Rossii*, and in no case has crystallised eudesmol been detected in the oil of this species under natural conditions.

In the first edition of this work, page 71, we describe the oil of *E. Rossii* from two localities in New South Wales (Bathurst and Bungendore), and show the presence of a highly dextro-rotatory constituent in the higher-boiling portions of both, that from Bathurst being  $\alpha_D + 19.19^\circ$ , and the other almost as high. These samples were mixed and stored in the dark, and twenty years afterwards the oil was again analysed. The highly dextro-rotating constituent, when finally distilled under reduced pressure at 10 millimetres, slowly crystallised and was found to be eudesmol melting at 79–80°, and to have specific rotation  $[\alpha]_D + 33.58^\circ$  in a 12 per cent. chloroform solution. It is thus seen that the liquid form of eudesmol is an exceedingly stable substance, particularly as it was somewhat readily separated in the crystalline condition after the lapse of twenty years.

We have so far detected either the liquid or crystallised eudesmol in the oils of forty-two species of Eucalyptus, and have prepared the crystallised form in the pure condition from several. It is a coincidence, perhaps, that in twenty-one

of these it was associated with phellandrene, whilst the other twenty-one did not contain that terpene. In the following lists the two classes are separated for purposes of comparison :—

| Eucalyptus oils containing crystallised eudesmol<br>in which phellandrene was ABSENT.                                                                                                                                                                                                                                                          | Eucalyptus oils containing crystallised eudesmol<br>in which phellandrene was PRESENT.                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Eucalyptus accedens.</i><br><i>E. Baeuerleni.</i><br><i>E. camphora.</i><br><i>E. elæophora.</i><br><i>E. globulus*.</i><br><i>E. goniocalyx.</i><br><i>E. Gullicki.</i><br><i>E. lactea.</i><br><i>E. ligustrina.</i><br><i>E. Macarthuri.</i><br><i>E. Moorei.</i><br><i>E. phlebophylla.</i><br><i>E. Smithii.</i><br><i>E. stricta.</i> | <i>Eucalyptus amygdalina</i> var. <i>nitida.</i><br><i>E. campanulata.</i><br><i>E. coccifera.</i><br><i>E. coriaceæ.</i><br><i>E. fastigata.</i><br><i>E. fraxinoides.</i><br><i>E. hæmastoma.</i><br><i>E. Luehmanniana.</i><br><i>E. macrorhyncha.</i><br><i>E. melanophloia.</i><br><i>E. oreades.</i><br><i>E. phellandra.</i><br><i>E. piperita.</i><br><i>E. regnans.</i><br><i>E. tæniola.</i><br><i>E. virgata.</i> |

\*Although *E. globulus* is included in this list, yet, Schimmel & Co. (semi-annual report, April, 1904, 51), suggest that this substance (eudesmol) differs in certain directions from ordinary eudesmol, and Semmler proposes for it the name globulol. It was thought that similar relations existed between eudesmol and globulol as between borneol and iso-borneol.

Much Eucalyptus oil, however, supplied commercially under the name of *Eucalyptus globulus* had not been distilled from that species, and this difficulty was early recognised by Bourchardat and Tardy during their investigations on the terpene of *E. globulus*. [Compt. Rend. 120 (1895), 1417.]

The oils of the following Eucalypts appear to contain only the liquid form of eudesmol under natural conditions :—

| Eucalyptus oils containing liquid eudesmol<br>WITHOUT phellandrene.                                                                                                | Eucalyptus oils containing liquid eudesmol<br>together WITH phellandrene.                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <i>Eucalyptus Behriana.</i><br><i>E. dealbata.</i><br><i>E. eximia.</i><br><i>E. maculosa.</i><br><i>E. parvifolia.</i><br><i>E. Rodwayi.</i><br><i>E. Rossii.</i> | <i>Eucalyptus cærulea.</i><br><i>E. Consideniana.</i><br><i>E. Gunnii.</i><br><i>E. linearis.</i><br><i>E. pilularis.</i> |

#### METHOD OF PREPARATION OF EUDESMOL.

For the preparation of pure crystallised eudesmol from a freshly distilled Eucalyptus oil, rich in the stearoptene, the following method was adopted as being the most convenient. Constituents boiling below about 220° C. were removed from the crude oil by distillation, and the remainder poured into shallow vessels to crystallise. The soft buttery-like crystalline mass thus obtained was



then spread upon porous plates to absorb as much of the adhering liquid as possible. The solid whitish product which remained was dissolved in alcohol, filtered if necessary, water slowly added until a permanent turbidity remained, and the whole left in open vessels to crystallise. On standing thus for one or two days the eudesmol crystallised out very well, and could then be removed as a solid cake from the mother liquor. It was spread on porous plates as before, and the process repeated until a perfectly snow-white crystalline product remained. Eudesmol as thus obtained is exceedingly light and bulky, of a silky lustre, and acicular crystals at times well developed, which when sufficiently transparent polarise very well with parallel extinction.

With several Eucalyptus oils, *E. camphora*, *E. Gullicki*, *E. macrorhyncha* and *E. virgata*, for instance, it was possible to obtain the crude eudesmol during the primary distillation, by first separating the more volatile constituents in the leaf, then raising considerably the steam pressure in the digester and continuing the distillation for two or three hours longer. After standing some hours this latter distillate crystallised as a solid cake, from which the pure eudesmol was prepared as described above.

#### CHEMICAL AND PHYSICAL PROPERTIES OF EUDESMOL.

Semmler and Tobias (*loc. cit.*) give the following constants which they had determined for eudesmol:—melting point  $78^{\circ}$  C.; boiling point  $156^{\circ}$ , at 10 millimetres pressure; specific gravity at  $20^{\circ} = 0.9884$ ; specific rotation in a 12 per cent. solution of chloroform  $[\alpha]_D + 31.21^{\circ}$ ; refractive index at  $20^{\circ} = 1.516$ , molecular refraction calculated for  $C_{15}H_{26}O$  with one double bond = 68.07; found 67.85.

They point out that from the molecular refraction eudesmol evidently contains two rings and one double bond.

When eudesmol was acetylated it yielded an acetate boiling at  $165$  to  $170^{\circ}$  at 11 millimetres pressure. Reduction with hydrogen and platinum black gave dihydro-eudesmol, an alcohol melting at  $82^{\circ}$  and boiling at  $155$ – $160^{\circ}$  at 12.5 millimetres, and the acetate from this boiled at  $158$ – $164^{\circ}$  at 10 millimetres.

When boiled with absolute formic acid dihydro-eudesmol gave dihydro eudesmene, a body boiling at  $126$ – $130^{\circ}$  at 10 millimetres.

When boiled with 90 per cent. formic acid eudesmol was converted into eudesmene, which substance boiled at  $129$ – $132^{\circ}$  at 10 millimetres; had specific gravity at  $20^{\circ} = 0.9204$ ; specific rotation at  $20^{\circ} [\alpha]_D + 49^{\circ}$ ; and refractive index at  $20^{\circ} = 1.50738$ . The molecular refraction from this shows clearly that the sesquiterpene contains two rings and two double bonds, and belongs to that group of sesquiterpenes which is derived from hydrogenated naphthalene. When eudesmol was shaken with hydrogen chloride glacial acetic acid, eudesmene dihydrochloride was formed; this substance melted at  $79$ – $80^{\circ}$  and was identical with the hydrochloride which was formed by the addition of hydrogen chloride to eudesmene.

Later, Semmler and F. Risse (*loc. cit.*) undertook further investigations with eudesmene, which they had prepared by saturating a solution of eudesmol in glacial acetic acid with hydrochloric acid. On evaporating this solution in vacuo at  $50$ – $60^{\circ}$ , eudesmene dihydrochloride was obtained, and this when purified from alcohol melted at  $70^{\circ}$ . It was then boiled with alcoholic potash under a reflux, the resulting product being eudesmene, possessing the following properties:—Boiling point  $122$ – $124^{\circ}$  at 7 millimetres pressure; specific gravity at  $20^{\circ} = 0.9196$ ; specific rotation  $[\alpha]_D + 54.6^{\circ}$ ; refractive index at  $20^{\circ} = 1.50874$ . When the acetic acid solution was reduced with hydrogen in the



presence of platinum, tetrahydroeudesmene was formed. This had boiling point 122–122.5° at 7.5 millimetres; specific gravity at 20° = 0.8893; specific rotation  $[\alpha]_D + 10.12^\circ$ , and refractive index at 20° = 1.48278.

It was also shown that the reduction of eudesmol by hydrogen in the presence of platinum proceeded differently in an ethereal solution to what it did in the presence of glacial acetic acid; in the former case the hydrogenation only led to dihydroeudesmol, while in the latter case both the double bond and the hydroxyl group were replaced by hydrogen.

We have found the hydroxyl group in eudesmol to be very unreactive, except in the case of acetic anhydride, and have failed to combine it with phthalic anhydride, benzoic acid anhydride, benzoyl-chloride, or phenyl-isocyanate.

#### SPECIFIC ROTATIONS OF EUDESMOL.

The specific rotations of crystallised eudesmol which we have prepared from the oils of the various *Eucalyptus* species enumerated below, taken in each case in about 12 per cent. chloroform solution, were not always of the same value, as seen from the following results:—

|                   |                     |     |     |     |     |                            |
|-------------------|---------------------|-----|-----|-----|-----|----------------------------|
| <i>Eucalyptus</i> | <i>hæmastoma</i>    | ... | ... | ... | ... | $[\alpha]_D + 38.43^\circ$ |
| <i>E.</i>         | <i>Moorei</i> ...   | ... | ... | ... | ... | „ 35.50°                   |
| <i>E.</i>         | <i>Gullicki</i>     | ... | ... | ... | ... | „ 33.65°                   |
| <i>E.</i>         | <i>Rossii</i> ...   | ... | ... | ... | ... | „ 33.58°                   |
| <i>E.</i>         | <i>Macarthuri</i>   | ... | ... | ... | ... | „ 31.75°                   |
| <i>E.</i>         | <i>ligustrina</i>   | ... | ... | ... | ... | „ 30.02°                   |
| <i>E.</i>         | <i>phlebophylla</i> | ... | ... | ... | ... | „ 27.07°                   |

After two years the comparatively unaltered sample of crystallised eudesmol from *E. Macarthuri*, mentioned previously, had however lowered slightly in specific rotation to  $[\alpha]_D + 30.46^\circ$ . When distilled at 10 millimetres, the product had again risen to  $[\alpha]_D + 31.68^\circ$ , and thus in agreement with that of the original determination. That two optical isomers are present in ordinary eudesmol is indicated from the above, and also from the results obtained with the sublimed crystals from the liquid eudesmol of *E. Macarthuri*, as illustrated previously. The specific rotation of the sublimed product was  $[\alpha]_D + 37.64^\circ$ , and that of the transparent light amber coloured, brittle residue  $[\alpha]_D + 24.93^\circ$ . The mean of these results is  $[\alpha]_D + 31.28^\circ$ , almost identical with that for the original eudesmol.

#### MELTING POINT OF EUDESMOL.

The melting point of eudesmol is given by Semmler and Tobias as 78° C., but in all the samples of eudesmol we have prepared from the oils of different species of *Eucalyptus*, the melting point of the finally crystallised substance has been between 79–80° C. In some species the solid paraffin occurs, together with the eudesmol (*E. Moorei* for instance), and the melting point may thus easily be lowered. It may be removed by dissolving in alcohol, adding sufficient water to precipitate the paraffin, and filtering it off on a Buchner funnel by the pump.

When, however, the oil of *E. Macarthuri* was distilled under 10 millimetres pressure, the product thus obtained melted at 78°, and also at the same temperature when sublimed from the water bath, before recrystallising.

We are not aware from which species of *Eucalyptus* the eudesmol was obtained upon which Semmler and Tobias carried out their investigations, but from the specific rotations given above and also from the fact that the oil of *E. Macarthuri* is commercially distilled in Australia, the indications are that it might have been derived from that species.

## The Monohydric Alcohols of the $C_nH_{2n+1}OH$ Series occurring in Eucalyptus Oils.

THE abnormal solubility in alcohol shown by the oils of some species in which cineol is not pronounced, and phellandrene present in some quantity, points to the occurrence of an excess of alcoholic bodies not present in the more distinctly phellandrene-bearing oils of other Eucalypts. The comparatively high percentage of cineol in the oil of *E. phellandra* over those of *E. dives*, *E. radiata* and similar species, naturally assists this solubility, but that constituent is not present in sufficient amount to alone place the oil in the same class, as regards solubility, with those richest in cineol. The odour possessed by the oil of *E. phellandra* is somewhat aromatic, largely due to the presence of terpineol, and is perhaps characteristic of that species.

It was this peculiarity of solubility that induced us to carry out investigations in order to determine whether the earlier members of the monohydric alcohols were also present. The lower boiling aldehydes only occur in this oil in very small amount, and the peppermint ketone, piperitone, is not pronounced, so that those constituents cannot influence the solubility to any great extent. Both ethyl and amyl alcohols had previously been determined in a Eucalyptus oil (stated to be that of *E. globulus*) by Bouchardat and Olivier, and if no doubt exist as to the origin of the material worked upon by them, then these alcohols are more frequently present in the oils of the various species than has been supposed. Unfortunately, the products of the several species have not always been kept distinct. In the oil we obtained from *E. cinerea*, alcohols boiling below  $100^{\circ}C$ . did not appear to be present, and that species yields an oil belonging to the same group as that distilled from *E. globulus*.

Through the kindness of the Australian Eucalyptus Oil Company we were supplied with two litres of the water which first distilled on rectifying the oil of *E. phellandra* by direct distillation. The free acetic acid was first neutralised, and the water distilled, a Glynsky's fractionating column being used for the purpose.

The first distillation gave 88 cubic centimetres boiling between  $70^{\circ}$  and  $90^{\circ}C$ ., and 30 c.c. between  $90^{\circ}$  and  $95^{\circ}C$ . On again fractionating the portion distilling between  $70^{\circ}$  and  $90^{\circ}C$ ., 15 c.c. came over between  $70^{\circ}$  and  $76^{\circ}C$ .; between  $76^{\circ}$  and  $78^{\circ}C$ . only a very small amount was obtained; but between  $78^{\circ}$  and  $79^{\circ}C$ . no less than 26 c.c. distilled, and 5 c.c. more below  $80^{\circ}C$ . Although containing a small amount of aldehyde, yet the greater portion of the fractions was found to be alcohols. As the lower boiling alcohols distilled off, the liquid remaining in the flask separated into two layers, the upper one having an oily appearance. The 30 c.c. obtained in the first distillation, boiling between  $90^{\circ}$  and  $95^{\circ}C$ ., were then added, when the oily layer again dissolved; on again removing the lower boiling alcohols the oily substance again separated. The upper layer, which consisted principally of the higher homologues, was investigated separately.



On again rectifying the 46 c.c. which distilled between 70 and 80° C., 15 c.c. were obtained boiling below 76° C. This portion consisted principally of methyl and ethyl alcohols. The thermometer then rapidly rose to 78° C.; between 78 and 78.5° C. 15 c.c. distilled. This was found to consist mostly of ethyl alcohol; it was readily oxidised to acetaldehyde and then to acetic acid; it also formed ethyl acetate, and gave other chemical reactions for ethyl alcohol.

To prove the presence of methyl alcohol, the portion distilling below 76° C. was carefully oxidised, the acids distilled off in the usual way, and their barium salts prepared. The barium sulphate thus obtained was 95.18 per cent., indicating 13.56 per cent. of barium formate, and 86.44 per cent. barium acetate. The presence of formic acid was proved by its characteristic reactions, and an excellent silver mirror was obtained. Formic acid was also detected by M. Voiry in the oil of *E. globulus* (Compt. Rend. 1888, 1419). See also the article in this work on the free acids of Eucalyptus oils.

The liquid remaining in the flask, which had separated into two layers, was then distilled, and the portion which came over below 99° C. removed. On continuing the distillation, part of the "oily" layer came over with the steam, and partly separated again in the receiver. It was added to the upper portion still remaining in the flask. Valeraldehyde was shown to be present in this oily layer, and it was removed by combining it with acid sodium sulphite, and after separation oxidising it to valeric acid. The unacted-upon portion formed esters in the ordinary way, amyl-acetate being readily detected. On gentle oxidation the odour of butyric acid was obtained, but on energetic oxidation the acids formed were acetic and valeric. Ethyl alcohol could hardly have been present under the circumstances, so that the acetic acid shown to be present was apparently obtained by the oxidation of one of the alcohols. This points to the probable presence of iso-butyl alcohol existing as such in the original oil. Valeric acid was readily detected by its characteristic objectionable odour, when the salt was decomposed with sulphuric acid, and the formation of this acid points to the prior presence of amyl alcohol. Iso-amyl alcohol is a frequent constituent in Eucalyptus oils and is more pronounced in those intermediate between the pinene oils and those richest in cineol. A determination of the mixed barium salts of the oxidation product gave 86.8 per cent. barium sulphate, indicating 79.81 per cent. barium acetate and 20.19 per cent. barium valerate. The results of this determination with the first distillate from Eucalyptus *phellandra* indicated that methyl, ethyl, iso-butyl, and amyl alcohols were present. Normal butyric acid has also been found in the oils of other species of Eucalyptus. (See the article in this work on the Butyl ester of butyric acid.) Although the presence of the above enumerated monohydric alcohols was thus demonstrated, yet they were not in sufficient amount to account for the exceeding solubility of the oil, a character evidently due to the influence of the higher boiling alcohols. (See the article on the Terpeneols of Eucalyptus oils.)



## The Cyclic (Aromatic) Aldehydes occurring in Eucalyptus Oils.

Cuminal  $C_{10}H_{12}O$ , Aromadendral  $C_{10}H_{14}O$ , Cryptal  $C_{10}H_{16}O$ , and Another.

ONE or more members of this very interesting group of aromatic aldehydes occur in the oils distilled from the members of the typical "Box" group (*E. hemiphloia*, &c.) and chemically related "Mallees" (*E. polybractea*, &c.), as well as from other closely associated Eucalypts.\*

These aldehydes do not seem to occur in the oils of the earlier members of the genus (the pinene yielding group), nor in those of the more recent species, particularly those in which phellandrene is the more pronounced terpene. In these latter species the characteristic constituent is the ketone piperitone.

It thus appears that they are common to a large proportion of the oils of Eucalyptus species occupying the middle portion in the evolutionary sequence of the genus (groups IV and V), and they are so shown grouped together in the evolutionary table elaborated in this work.

It may also be stated as a general rule that cymene is present in either larger or smaller amount in the oils of species containing these aldehydes, and we have isolated this hydrocarbon from many of the oils of this class, and proved its identity chemically.

When the members of this aldehydic group are pronounced, at least two and sometimes three or them occur together, particularly at certain periods of the year; at other times the cuminal is practically absent, and it is probably due to this peculiarity that the conclusions of previous investigators have not been altogether in agreement. The presence of cuminal in the oils of certain Eucalypts was noticed many years ago.

Some members of the "Box" group yield an oil in which the terpene phellandrene can be detected at certain periods of the year, although absent at other times (*E. hemiphloia* for instance), and this has often been observed with species which are on the border line, as it were, of phellandrene production. One peculiarity which has been noticed is that when phellandrene can be readily detected in these oils, cuminal is present in greatest amount; and it was fortunate that in the work originally carried out on these aldehydes from the oil of *E. hemiphloia*, for the first edition of this work, the material was distilled at the time of the year when phellandrene could not be detected, and cuminal absent or only present in very small amount, consequently the aldehyde regenerated from the crystallised sulphite compound was at that time almost entirely aromadendral.

This diminution in the amount of cuminal, and the deficiency in phellandrene, is probably responsible to a certain extent for the formation of the dihydro- and tetrahydrocuminals, which can then be isolated from these oils.

Wallach has shown [Ann. 340 (1905) 12] that the oxidation of  $\beta$ -phellandrene produces a glycol, which on treating with dilute sulphuric acid gives dihydro- and tetrahydrocuminaldehydes. Molecular re-arrangement of a somewhat similar character may perhaps take place naturally under climatic conditions and the seasons' changes.

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\* In the first edition of this work, the optically active aldehydes peculiar to the oils of certain Eucalypts, were considered to be a single substance and named aromadendral. This name is retained in this edition to denote the occurrence of one or more members of this group of aldehydes.

The aldehyde cryptal had, up to quite recently, escaped us, because it does not form a solid compound with sodium bisulphite, and also because the liquid combination is not decomposed by sodium carbonate, so that in previous investigations it had been thrown away. As this aldehyde had eluded us for twenty years, it was decided to name it cryptal. Now that it has been found it is perhaps remarkable that it can be separated and isolated more satisfactorily than either cuminal or aromadendral, and consequently can be prepared in a state of purity.

Cuminal readily forms a solid compound when shaken with a 30 per cent. solution of sodium bisulphite, and aromadendral mostly combines in the solid form also, but cryptal only forms the liquid combination. The bisulphite compound with both cuminal and aromadendral is decomposed by sodium carbonate, but that with cryptal is not so changed, and a solution of sodium hydrate is required to set the aldehyde free. A further means of purification is that cryptal combines quantitatively with a 35 per cent. solution of neutral sodium sulphite in the cold, and in this way can be separated from the other aldehyde, which also forms a liquid bisulphite compound, and which agrees somewhat closely with the tetrahydrocuminal isolated by Schimmel & Co. from water fennel oil, and named by them phellandral. (Die Aetherischen Oele, 2nd Edition, p. 449.)

When thus prepared the analytical figures for cryptal were in agreement with the  $C_{10}H_{16}O$  molecule, and the molecular refraction worked out almost theoretically, a result not so far obtained with the other aldehydes of this group occurring in *Eucalyptus* oils.

Cuminal does not contain an asymmetric carbon atom, consequently it is optically inactive. Aromadendral evidently exists in both optical rotatory modifications, although, so far, the dextro-rotatory form has not been isolated. Cryptal also shows irregular optical rotations when isolated from the oils of different species, so that probably both forms of this aldehyde also occur.

This irregularity in optical rotations is indicated from the results obtained with the oils of species in which these aldehydes are pronounced, and the crude oils and fractions of the following species show this clearly.

The oil of *Eucalyptus hemiphloia*, New South Wales, distilled in September, gave the following results :—

|                                |     |     |     |     |     |     |     |       |   |          |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-------|---|----------|
| Crude oil                      | ... | ... | ... | ... | ... | ... | ... | $a_D$ | — | 6.8° C.  |
| Fraction boiling below 183° C. | ... | ... | ... | ... | ... | ... | ... | „     | — | 3.2° C.  |
| „ between 183–215° C.          | ... | ... | ... | ... | ... | ... | ... | „     | — | 10.3° C. |
| „ „ 215–230° C.                | ... | ... | ... | ... | ... | ... | ... | „     | — | 25.0° C. |

The oil of *Eucalyptus albens*, New South Wales, distilled in June, gave :—

|                                |     |     |     |     |     |     |     |       |   |          |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-------|---|----------|
| Crude oil                      | ... | ... | ... | ... | ... | ... | ... | $a_D$ | — | 6.5° C.  |
| Fraction boiling below 183° C. | ... | ... | ... | ... | ... | ... | ... | „     | — | 5.6° C.  |
| „ between 183–225° C.          | ... | ... | ... | ... | ... | ... | ... | „     | — | 6.0° C.  |
| „ „ 225–255° C.                | ... | ... | ... | ... | ... | ... | ... | „     | — | 14.6° C. |

The oil of *Eucalyptus salubris*, Western Australia, distilled in July, gave :—

|                              |     |     |     |     |     |     |     |       |   |          |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-------|---|----------|
| Crude oil                    | ... | ... | ... | ... | ... | ... | ... | $a_D$ | — | 5.8° C.  |
| Fraction between 168–172° C. | ... | ... | ... | ... | ... | ... | ... | „     | + | 6.8° C.  |
| „ „ 172–183° C.              | ... | ... | ... | ... | ... | ... | ... | „     | + | 0.5° C.  |
| „ „ 183–219° C.              | ... | ... | ... | ... | ... | ... | ... | „     | — | 8.9° C.  |
| „ „ 219–240° C.              | ... | ... | ... | ... | ... | ... | ... | „     | — | 30.1° C. |

The oil of *Eucalyptus rostrata*, South Australia, distilled in June, gave :—

|                              |     |     |     |     |     |     |     |       |   |          |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-------|---|----------|
| Crude oil                    | ... | ... | ... | ... | ... | ... | ... | $a_D$ | — | 12.4° C. |
| Fraction between 173–188° C. | ... | ... | ... | ... | ... | ... | ... | „     | — | 7.5° C.  |
| „ „ 188–255° C.              | ... | ... | ... | ... | ... | ... | ... | „     | — | 21.2° C. |



Corresponding results have also been obtained with the oils of other Eucalypts.

The crude oil of *E. cneorifolia*, one of the "Mallees" growing in South Australia, appears to be always lævo-rotatory when prepared by ordinary methods of distillation. This optical activity is also due to the presence of members of this aldehydic group.

The oils of most Eucalypts growing as "Mallees" contain one or more of these aldehydes, and these species are thus shown to be closely associated with the members of the "Box" group.

*Eucalyptus Woollsiana*, a species growing in the western portion of New South Wales, also contains these aldehydes in quantity, and in working out this species no less than six different distillations were made on material from various localities where it grows plentifully. These results will be found recorded under that species.

The prepared composite aldehydes, separated by sodium carbonate from the crystallised combination with sodium bisulphite, had the following specific rotations for the following species:—

|                            |     |     |     |     |         |          |
|----------------------------|-----|-----|-----|-----|---------|----------|
| <i>Eucalyptus salubris</i> | ... | ... | ... | ... | $[a]_D$ | — 90·45° |
| <i>E. rostrata</i>         | ... | ... | ... | ... | $[a]_D$ | — 73·94° |
| <i>E. hemiphloia</i>       | ... | ... | ... | ... | $[a]_D$ | — 49·19° |

So that no regularity in optical rotations is observed with the prepared aldehydes from different Eucalypts.

#### EXPERIMENTAL.

940 c.c. of the crude oil of *E. hemiphloia*, containing some phellandrene, distilled in March, 1920, was first agitated with a 5 per cent. solution of sodium hydrate to remove the phenols. (From these phenols pure crystallised australol was prepared.) It was afterwards distilled, and the portion boiling below 190° C. separated. The remainder was repeatedly shaken with a 35 per cent. solution of sodium bisulphite for six hours, the crystalline portion pumped off, purified by washing with ether-alcohol, and decomposed by sodium carbonate. The purified sodium sulphite compound weighed 49 grams, from which 24 c.c. of aldehyde were obtained. This had specific gravity at 24° C. = 0·970; optical rotation  $a_D$  — 20° C., and refractive index at 20° C. = 1·5222.

It was then distilled under reduced pressure, when 90 per cent. of the whole boiled at 106–108° C. at 10 millimetres pressure. This portion had the following constants:—Specific gravity at 15° C. = 0·9767; rotation  $a_D$  — 20·1°, and refractive index at 20° = 1·5232. The hydrazone melted at 126–127° C., and the semicarbazone at 210–211°. This aldehyde evidently consisted largely of cuminal, the optical activity being due to the aromadendral.

In an attempt to separate the lævo-rotatory aromadendral all but 5 c.c. were lost. This portion, however, gave constants even more closely approaching those for cuminal, and the rotation was only  $a_D$  — 5°.

The aqueous portion separated from the crystalline compound was treated with sodium carbonate solution, and the separated aldehyde extracted with ether. In this way 5 c.c. of aldehyde were obtained, and although consisting largely of aromadendral, yet it also contained cuminal, as is shown from the following figures:—It had specific gravity at 15° C. = 0·9703; rotation  $a_D$  — 28·5°, and refractive index at 20° = 1·5108. The semicarbazone melted at 204–205° C.

The remaining aqueous solution was then decomposed by treating with 10 per cent. solution of sodium hydrate, and the aldehyde extracted with ether; no less than 43 c.c. of aldehyde were obtained in this way. This had specific



gravity at 15° C. = 0.9471; rotation  $a_D$  — 98.4°, and refractive index at 20° = 1.4864. It was then distilled under reduced pressure, when 90 per cent. came over at 101–102° C. at 10 millimetres. It had the following constants:—

|                                |                 |
|--------------------------------|-----------------|
| Specific gravity at 20° C. ... | ... = 0.94165.  |
| Optical rotation $a_D$ ...     | ... — 98.24°.   |
| Refractive index at 20° C. ... | ... = 1.4858.   |
| Oxime melted at ...            | ... 84–85° C.   |
| Hydrazone melted at ...        | ... 119–120° C. |
| Semicarbazone melted at ...    | ... 173° C.     |

(Both the oxime and hydrazone were produced by the highly rotatory aldehyde allied to phellandral, because those formed with cryptal are liquid.)

The aldehyde thus prepared was then shaken with a 35 per cent. solution of neutral sodium sulphite at room temperature (20° C.), repeatedly neutralising the separated sodium hydrate with standard acid, until combination was complete. The uncombined aldehyde was then removed by ether, dried and weighed.

|                                       |                     |
|---------------------------------------|---------------------|
| Amount of original aldehyde taken ... | ... = 15.9822 gram. |
| „ „ „ uncombined ...                  | ... = 5.9074 „      |
| „ „ „ combined ...                    | ... = 10.0748 „     |

This result was very satisfactory for an aldehyde with the  $C_{10}H_{16}O$  molecule. The combined aldehyde was regenerated from the aqueous solution by sodium hydrate, extracted with ether and prepared in the usual way. The constants, with varying degrees in optical rotation with the different species, are those for cryptal.

|                                     |                 |
|-------------------------------------|-----------------|
| Specific gravity at 20° C. ...      | ... = 0.9431.   |
| Optical rotation $a_D$ ...          | ... — 76.02°.   |
| Refractive index at 20° C. ...      | ... = 1.4830.   |
| Boiling point at 10 millimetres ... | ... 98–100° C.  |
| „ „ 760 „ ...                       | ... 221° C.     |
| Semicarbazone melted at ...         | ... 176–177° C. |

The oxime and hydrazone were both liquid, and so far we have not succeeded in forming these in a satisfactory crystallised condition.

The aldehyde which did not combine with neutral sodium sulphite in the cold, and was not decomposed by sodium carbonate, had a remarkably high rotation. It gave the following constants:—

|                                                       |                 |
|-------------------------------------------------------|-----------------|
| Specific gravity at 20° C. ...                        | ... = 0.9408.   |
| Optical rotation $a_D$ ...                            | ... — 130.6° C. |
| Refractive index at 20° C. ...                        | ... = 1.4901.   |
| Boiling point at 10 millimetres ...                   | ... 102–103° C. |
| Oxime melted at ...                                   | ... 87–88° C.   |
| Hydrazone melted at ...                               | ... 119–120° C. |
| Semicarbazone melted at ...                           | ... 204–205° C. |
| When oxidised by means of air, the acid melted at ... | ... 137–138° C. |

These figures closely agree with those given for phellandral; the aldehyde had evidently the  $C_{10}H_{16}O$  molecule with one double linkage.

On the completion of the above work it was decided to procure fresh material of *E. hemiphloia*, for purposes of comparison. As the date of collection was less than four weeks from the above, but little differences were observed from those already given, except that the cuminal fraction was but —11.8°. The same mode of procedure was adopted throughout as in the previous case. The aldehyde

cryptal, when finally separated, gave almost identical results with the previous sample, and are recorded here for purposes of comparison :—

|                                   | Cryptal from<br>first sample. | Cryptal from<br>second sample. |
|-----------------------------------|-------------------------------|--------------------------------|
| Specific gravity at 20° C. ... .. | = 0.9431                      | = 0.9426                       |
| Optical rotation $a_D$ ... ..     | — 76.02°                      | — 76.20°                       |
| Refractive index at 20° C. ... .. | = 1.4830                      | = 1.4830                       |
| Boiling point at 10 m.m. ... ..   | 98–100° C.                    | 99–100° C.                     |
| Semicarbazone melted at ... ..    | 176–177° C.                   | 176–177° C.                    |

The oximes and hydrazones were liquid in both cases.

The molecular refraction calculated for a  $C_{10}H_{16}O$  aldehyde with one double bond is 45.82; found 45.99.

The combustion results for cryptal were as follows :—0.1729 gram. gave 0.4982 gram.  $CO_2$ , and 0.1638 gram.  $H_2O$ . C. = 78.58, and H. = 10.52 per cent  $C_{10}H_{16}O$  requires 78.94 C. and 10.53 H.

The total amount of aldehydes belonging to this group, extracted from the crude oil of *E. hemiphloia*, was equal to 10 per cent.

#### CRYPTAL FROM THE OIL OF *E. POLYBRACTEA*.

The residues obtained on rectifying, for commercial purposes, the oil of this species by steam, were employed for the purpose of determining the aldehydes of this Eucalyptus. The procedure adopted was that described above. A small amount of cuminal containing some aromadendral was isolated. This gave the following constants: Specific gravity at 20° C. = 0.9735; rotation  $a_D$  — 3.6°; refractive index at 20° = 1.5250. The hydrazone melted at 126–127° C., and the semicarbazone at 210–211°.

The cryptal, when recovered from the neutral sodium sulphite, had a less rotation than that from *E. hemiphloia*, and gave a semicarbazone which melted at a slightly higher temperature, otherwise the figures were in agreement. To confirm this result, a fresh quantity of cryptal was isolated. The constants for these two samples were as follow :—

|                                   | Cryptal,<br>first sample. | Cryptal,<br>second sample. |
|-----------------------------------|---------------------------|----------------------------|
| Specific gravity at 20° C. ... .. | = 0.9443                  | = 0.9446                   |
| Optical rotation $a_D$ ... ..     | — 49.7°                   | — 50.2°                    |
| Refractive index at 20° C. ... .. | = 1.4849                  | = 1.4842                   |
| Semicarbazone melted at ... ..    | 180° C.                   | 180° C.                    |

The oximes and hydrazones were liquid in both cases.

Although cryptal can thus be so well isolated, yet methods have not so far been devised whereby aromadendral and cuminal may be separated from each other in a pure condition; so that the true constants for aromadendral cannot be given with certainty. In the work undertaken for the first edition, the aldehyde was extracted from the oil of *E. hemiphloia*, distilled in September,



and the purified crystalline sulphite compound decomposed by sodium carbonate. At that time of the year phellandrene was not detected, and cuminal was almost absent.

The constants for aromadendral from *E. hemiphloia* at that time were:—Specific gravity = 0.9477; rotation  $a_D$  — 46.6°, and refractive index at 20° = 1.5086. The oxime melted at 84–85° C., the naphthocinchoninic acid at 247° C., and the acid at 110° C. In the light of the present investigation it is apparent that a little cuminal was present also, and this is indicated by the figures given above. The analysis, however, gave results closely agreeing with those required for a  $C_{10}H_{14}O$  aldehyde, and the acid was also in agreement with the  $C_{10}H_{14}O_2$  molecule.

As the total amount of aldehydes extracted at that time only amounted to 3.3 per cent., it is evident that crystal was not included.

The  $C_{10}H_{14}O$  aldehyde occurring in Eucalyptus oils was originally named aromadendral (Proc. Roy. Soc., N.S.W., Dec. 1900), derived from the name aromadendron given to the genus by Dr. W. Anderson, the surgeon of Captain Cook's second and third expeditions.

The constants for aromadendral from the oil of *E. rostrata* prepared from the crystallised sulphite compound were:—Specific gravity at 20° C. = 0.9534; optical rotation  $a_D$  — 70.72; refractive index at 20° = 1.5066. The oxime melted at 84–85° C. It is thus apparent that a little cuminal was present here also. When aromadendral shall have been separated in a pure condition, it seems probable that the refractive index will be about 1.5 and the specific gravity about 0.95 at 20° C.

## Citral.

THIS constituent, found in some Eucalyptus oils, is one of the olefine terpene aldehydes, and because of its close relationship to geraniol is sometimes named geranial; it can be obtained artificially from geraniol by careful oxidation with the ordinary chromic acid mixture. Citral is evidently formed in the oils of some species of Eucalyptus by natural oxidation of the geraniol, and this is very well shown with those of *E. Australiana*, *E. phellandra*, &c.

In the Nerrigundah, or South Eastern part of New South Wales, the oil of *E. Australiana* contains geraniol in the free condition, and also as an ester, but only to a small extent. In the Burruga district of the same State, about 200 miles from the first locality, some of the geraniol, common to this species, has oxidised naturally to citral, and this feature is so characteristic that the secondary lemon odour of the oil of *E. Australiana* from the Burruga district is usually a sufficient test by which to indicate the locality where the oil had been distilled.

Geraniol is such a common constituent in Eucalyptus oils that it might perhaps be expected that citral would often occur, but this is not so, and only very occasionally has it been found in the oils of the Eucalypts. The species, the oil of which contains citral in greatest abundance, is *E. Staigeriana*, a Queensland tree. (See under that species in this work.)

Citral has a distinct lemon odour, so that its presence in a Eucalyptus oil can usually be detected, and as it boils at a high temperature (228–230° C. at atmosphere pressure) it is possible to largely concentrate it in the higher boiling portions. Citral, similarly with most aldehydes, can be isolated by agitating the



oil with a solution of sodium bisulphite, and after purification of the bisulphite compound by washing with ether and alcohol, the aldehyde set free from this by decomposing with sodium carbonate. The aldehyde may also be isolated in almost quantitative return by agitating with 35 per cent. neutral sodium sulphite solution, and regenerating with sodium hydrate.

For confirmation, the regenerated citral may be converted into the citryl- $\beta$ -naphthocinchonic acid by Doebner's reaction. This is carried out in the following manner:—

20 parts pyrotartaric acid, and 20 parts of the oil in question are dissolved in absolute alcohol; to the solution 20 parts of  $\beta$ -naphthylamine are added and the mixture boiled under a reflux for about three hours on the water bath. The crystalline acid which separates on cooling is then purified, when it will be found to melt at 197–200° C.

Citral is optically inactive; boils at 110–112° under 12 millimetres pressure, and is readily soluble in alcohol.

The sample we prepared from the oil of *E. Australiana* had specific gravity at 15° C. = 0.894, and refractive index at 20° C. = 1.4875.

## Citronellal.

THIS characteristic aldehyde is also one of the olefine terpene series. It occurs most abundantly in the oil of *Eucalyptus citriodora*, in fact at most times of the year it is found to contain over 90 per cent. of citronellal. The oil of this species has the distinctive odour of that aldehyde, and in this respect is quite different from any other known *Eucalyptus* oil. Citronellal is a very useful substance for perfumery purposes, particularly as it can be reduced to the corresponding alcohol citronellol, which substance has even a more pronounced rose odour than has geraniol. Citronellal has the formula  $C_{10}H_{18}O$  and contains one double bond.

It combines with sodium bisulphite, from which it is separated by alkali carbonates, and in this way citronellal may be prepared in a pure condition; it is, however, very sensitive towards both alkalis and acids.

Its identity may be determined by the formation of the semicarbazone, melting at 84° C.; as well as by the preparation of the citronellyl- $\beta$ -naphthocinchonic acid by Doebner's reaction. When finally crystallised from alcohol this substance melts at 225° C.

Citronellal differs from citral in being optically active, although the product from *E. citriodora* usually shows but slight activity, and probably consists of a mixture of both optically active modifications. It boils at 205–208° under atmospheric pressure, and at 89 to 91° at 14 millimetres; has specific gravity at 15° C. = 0.8556; and refractive index at 20° = 1.4481.

Citronellal in *Eucalyptus* oils may be quantitatively determined by absorption in a 30 per cent. commercial sodium bisulphite solution, using a flask with a narrow graduated neck; 5 c.c. of the oil may be taken, agitated with the bisulphite solution, and then heated on the water bath with frequent shaking, until absorption is complete. The unabsorbed portion is then lifted into the neck, read off, and subtracted from the amount taken, which multiplied by 20 gives the percentage of citronellal in the oil.

## Piperitone, the Peppermint Ketone of Eucalyptus Oils.

THIS unsaturated aromatic ketone is more generally distributed in the oils of Eucalypts growing in the Eastern and South Eastern portion of the continent, and in Tasmania, where the members of the whole group are known vernacularly as "Peppermints."

This peppermint odour was noticed by the first white settlers in Australia in 1788, and oil was distilled by them at that time, from the leaves of *Eucalyptus piperita*, a tree somewhat extensively distributed around Sydney, the coastal ranges, and coastal districts of New South Wales and Victoria. It is thus worthy of notice that both the vernacular name ("Peppermint") and the scientific name (*Eucalyptus piperita*) were given to this tree on account of the presence of this peppermint constituent in the oil; in fact, chemical constituents were often a guiding factor in the early naming of Eucalypts.

On the mountain ranges in New South Wales and Victoria, as well as in Tasmania, the members of the "Peppermint" group of Eucalypts form a large proportion of the natural vegetation, and are distributed over hundreds of square miles of country.

It is now recognised that all the principal constituents found in Eucalyptus oils increase in amount through a range of species until a maximum is reached in one or more of them. Piperitone follows this rule, and *Eucalyptus dives*, a "Broad-leaved Peppermint," appears to be the species in which it reaches a maximum content. This Eucalypt is one of the most plentiful of all the members of the "Peppermint" group, and also gives a good yield of oil, averaging from 3 to 4 per cent. according to the time of year, the care taken in collecting, and on the duration of the primary distillation, and if this be somewhat extended, say from 6 to 8 hours, the oil will often contain as much as from 40 to 50 per cent. of piperitone. It is thus evident that this ketone could be produced in great quantity, and at a cheap rate. The remainder of the oil of *E. dives* consists largely of phellandrene, and is employed in the mining industry for flotation work, as well as for other economic purposes.

Piperitone is the only ketone found in Eucalyptus oils; it was first isolated by one of us, and the results of a preliminary chemical investigation submitted to the Royal Society of New South Wales, in October, 1900. It was named piperitone by us in the first edition of this work.

Piperitone appears to occur only in the oils of species occupying the more recent end of the genus, and is not found in the oil of any member of the groups occupying the anterior position in the evolutionary sequence of the genus.

Although piperitone is usually found occurring with phellandrene, yet, in the case of *E. apiculata*, this terpene was not detected; and altogether the oil of this species was of such a character as not to be readily placed in any of the well defined groups.

In the oils of most species piperitone is found associated with the corresponding lævo-rotatory secondary alcohol piperitol, and we have isolated this alcohol from the oil of *E. radiata*, where it occurs as a well-defined constituent.

Under natural conditions piperitone is lævo-rotatory, but readily forms the racemic modification when heated above its boiling point, in the process of separation by direct distillation of the original oil. This alteration appears to be



brought about largely by the influence of the acid from the esters, under the conditions stated, because the pure ketone undergoes little alteration when distilled directly, but if geranyl-acetate be first added the alteration in rotation is considerable.

It was due to this tendency to racemisation that in the original paper, the ketone was shown to be inactive, as it had been first obtained in the crude condition by direct distillation of the original oil. If, however, the first separation be carried out under greatly reduced pressure, the lævo-rotatory form can be separated and prepared in a pure condition by the aid of sodium bisulphite. This compound of piperitone is very soluble in aqueous solution, but after the lapse of several days the saturated liquid forms a crystalline mass from which pure piperitone can be recovered, although there is often a considerable reduction in rotation. Piperitone can also be removed by the aid of the neutral sodium sulphite.

Piperitone has considerable prospective economic value, in that it forms thymol by treatment with ferric chloride; inactive menthone by reduction, when a nickel catalyst is employed; and inactive menthol by the reduction of the menthone with sodium in an aqueous ether solution. (These reactions were first shown by H. G. Smith and A. R. Penfold in a paper read before the Royal Society of New South Wales, June, 1920.)

As piperitone can be obtained in very large quantity, the production of one or more of these substances from this ketone, on a manufacturing scale, seems most promising, and should be profitable when the best conditions for commercial purposes shall have been worked out.

Piperitone being an unsaturated ketone with one double bond, it follows, from the above, that it must be a menthenone with the carbonyl group in the 3 position. This is proved by the formation of thymol and menthone. When piperitone is oxidised in the cold with potassium permanganate in alkaline solution, iso-butyric acid is one of the products of oxidation, and it does not seem possible to entirely prevent the formation of this acid at any stage of the process, even when the temperature is kept down by the addition of ice, and the theoretical amount of permanganate employed. From the ready formation of iso-butyric acid it might be supposed that the double bond was in the 4 position, but so far the corresponding  $\beta$ -methylglutaric acid has not been prepared.

Wallach and Meister [Ann. 362 (1908) 261] have, however, shown that  $\Delta$ -4-menthenone-3 boiled at  $212-213^{\circ}$  C., but Auwers [Ber. 41 (1908) 1801, and 42 (1909) 2408] doubts the correctness of this statement, although Wallach (Chem. Lentr., 1912, 11, 922-923) confirmed his original determination. The question whether piperitone is  $\Delta$ -4-menthenone-3, or  $\Delta$ -1-menthenone-3, remains at present unsettled, and the formation of menthone and menthol does not assist in deciding the position of the double bond.

Piperitone has a peppermint odour and taste, resembling pulegone very closely in these respects. It is colourless when pure, but becomes yellowish with age. It reduces an alkaline solution of silver nitrate and reproduces the red colour with Schiff's reagent.

#### PREPARATION OF LAEVO-ROTATORY PIPERITONE.

200 c.c. of an ordinary commercial oil of *E. dives* were subjected to distillation under reduced pressure, and after the removal of the lower boiling terpenes, two fractions were obtained boiling at 11 millimetres pressure :—

|                                  |                               |
|----------------------------------|-------------------------------|
| 52 c.c. at $105-109^{\circ}$ C.; | ketone content = 76 per cent. |
| 32 c.c. at $110-112^{\circ}$ C.; | „ = 92 „                      |



These two fractions were repeatedly distilled at 11 millimetres until a portion, boiling at  $108^{\circ}$  C. and containing 98 per cent. ketone, was obtained. This had specific gravity at  $15^{\circ}$  C. = 0.9392; rotation  $a_D - 50.02^{\circ}$ , and refractive index at  $20^{\circ}$  = 1.4850.

Another commercial sample of oil of *E. dives* was first distilled under reduced pressure and the ketone fraction separated; the piperitone was then prepared in the pure condition by the aid of sodium bisulphite. This had specific gravity at  $20^{\circ}$  C. = 0.9348; rotation  $a_D - 40.05^{\circ}$ ; refractive index at  $20^{\circ}$  = 1.4837, and boiled at  $106-107^{\circ}$  under 10 millimetres pressure, and at  $229-230^{\circ}$  (uncorr.) at 760 millimetres.

There appears to be no uniformity in optical rotation with the several samples of piperitone which have so far been separated, and it is thus evident that the left rotation is only the predominant form.

Analysis of piperitone showed the formula to be  $C_{10}H_{16}O$ .

0.1064 gram. gave 0.3067  $CO_2$  and 0.1030  $H_2O$ .

C. = 78.62, and H. = 10.75 per cent.

$C_{10}H_{16}O$  requires C. = 78.94, and H. = 10.53 per cent.

The molecular refraction calculated for a  $C_{10}H_{16}O$  ketone with one double bond, is 45.82; found 46.49. It has been shown by Auwers and Hessenland [Ber. 41 (1908) 1812] that menthenones of this character, with a conjugated double bond, require an addition of 0.83 to the aggregate, and if this addition be made for piperitone the result is closely theoretical.

The reaction with bromine in chloroform solution showed the molecule to be unsaturated. The bromine was absorbed in quantity, but eventually gave off hydrobromic acid.

The bromide was a heavy mobile oil, and on analysis gave a return of 58.9 per cent. bromine.

$C_{10}H_{16}Br_2O$  contains 51.2 per cent. Br., and  $C_{10}H_{15}Br_3O$ , 61.3 per cent. Br.

With hydroxylamine, piperitone gave a normal oxime and an oxaminoxime, the former melting at  $110-111^{\circ}$  C. and the latter at  $169-170^{\circ}$  C., the oxaminoxime readily decomposed Fehling's solution, and when boiled with mercuric oxide in alcoholic solution, the mixture assumed a blue colour due to the formation of a nitroso-compound from the  $NHOH$  group.

The semicarbazone, prepared with piperitone which had been regenerated from the bisulphite compound, melted at  $219-220^{\circ}$  C. If it had been prepared with the ketone obtained directly by repeated distillation under reduced pressure, two semicarbazones were formed, the least soluble of these melting at  $175-176^{\circ}$  C. and the more soluble at  $182-183^{\circ}$ . The latter was always tinted yellow. The semicarbazones can thus be prepared in three modifications.

#### REDUCTION OF PIPERITONE.

When the ketone is reduced by sodium-amalgam in alcoholic solution, large quantities of a dimolecular ketone are formed, the bulk of the reaction taking this direction. This substance crystallises well, melts at  $149$  to  $150^{\circ}$  C. and has the formula  $C_{20}H_{34}O_2$ . This reaction is due to the conjugated double bond, and it is worthy of notice that Carvone, with a double bond at 6 and the carbonyl at 1, also forms a dimolecular ketone melting at  $148-149^{\circ}$  C.

The dimolecular ketone with piperitone, can, however, be separated into two bodies, melting at different temperatures. When dissolved in chloroform and fractionally precipitated with ether, and the process repeated several times, one set of crystals melted at  $135-136^{\circ}$ , and the other at  $166-167^{\circ}$  C. Both were optically inactive.

Analysis of the dimolecular ketone, purified from alcohol, gave the following result :—

0.150 gram. gave 0.4298 gram.  $\text{CO}_2$  and 0.1568 gram.  $\text{H}_2\text{O}$ .

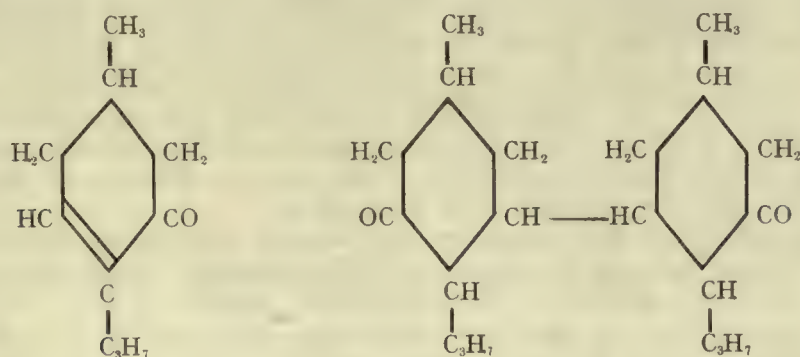
C. = 78.20 and H. = 11.60 per cent.

$\text{C}_{20}\text{H}_{34}\text{O}_2$  contains C. = 78.36 and H. = 11.21.

A molecular weight determination by the freezing method, using benzene as solvent, gave 308 ; by the Landsberger boiling method, using acetone, it was 306.

The oxime formed with the dimolecular ketone was very insoluble in all the usual neutral organic solvents, but was soluble in glacial acetic acid, separating again on dilution. The dioxime was prepared by adding an excess of hydroxylamine hydrochloride to 5 gram. of the dimolecular ketone in boiling absolute alcohol, and adding slowly 5 gram. potassium hydrate in 10 c.c. water. On boiling under a reflux for some time the compound separated, and was purified by boiling in alcohol and in water. The dioxime was a white crystalline powder and melted at  $245^\circ\text{C}$ . Almost a theoretical percentage of nitrogen for  $\text{C}_{20}\text{H}_{36}\text{N}_2\text{O}_2$  was obtained both by Dumas' and Kjeldahl's methods.

Piperitone and the dimolecular ketone have most probably the following molecular structures :—



#### PREPARATION OF MENTHONE AND MENTHOL FROM PIPERITONE.

When piperitone was reduced with purified hydrogen in the presence of a nickel catalyst, at a temperature of about  $180^\circ\text{C}$ . for six hours, the double bond was opened out, and, under the best conditions, menthone formed in almost quantitative yield; continuation of the treatment did not, however, result in the reduction of the carbonyl group even after two days. The menthone thus prepared had all the properties of this ketone and gave its characteristic chemical reactions and compounds. It also formed inactive menthol, melting at  $34^\circ\text{C}$ ., when reduced by sodium in aqueous ether solution.

Piperitone could also be partly reduced to inactive menthol directly by the action of sodium and aqueous ether, but the yield was poor, as large quantities of the dimolecular ketone were formed at the same time. The menthol was separated from the other substances by combining it with phthalic anhydride in the usual way. As thus prepared it crystallised very well and melted at  $34^\circ\text{C}$ .

Pickard and Littlebury [Journ. Chem. Soc., 101 (1912) 109] have shown that the inactive menthol melting at  $34^\circ\text{C}$ . can be split into lævo-rotatory menthol melting at  $43^\circ\text{C}$ . and dextro-rotatory menthol melting at the same temperature.



#### PREPARATION OF THYMOL FROM PIPERITONE.

60 gram. piperitone were added to a solution of 175 gram. ferric chloride, 160 c.c. glacial acetic acid, and 500 c.c. water. The whole was then heated on the sand bath to boiling. The action takes place according to the equation  $2 \text{FeCl}_3 + \text{H}_2\text{O} = 2 \text{FeCl}_2 + 2 \text{HCl} + \text{O}$ , and was completed at the expiration of about one hour. The reaction product was then steam distilled, the phenol separated and absorbed in a 5 per cent. solution of sodium hydrate, the unabsorbed oil removed by ether, and the aqueous layer decomposed by hydrochloric acid. The phenol was then distilled under reduced pressure, when the thymol came over at 110–111° C. at 10 millimetres. In this way a 25 per cent. yield of the weight of piperitone taken was recovered, but further researches will no doubt result in a much better yield being obtained. The thymol thus produced was identical in every way with the ordinary commercial article, and gave the chemical reactions for that substance.

#### QUALITATIVE AND QUANTITATIVE DETERMINATION OF PIPERITONE.

The presence of piperitone can be determined somewhat readily in Eucalyptus oils, as the crystalline compound formed when treated with sodium-amalgam in ether-alcohol solution is quite characteristic. The crude oils of some species, particularly that of *E. dives*, may be employed directly, but those in which piperitone is only present in small amount should first be fractionated. 10 c.c. of the oil are added to twice the volume of a mixture of ether and alcohol, or even 90 per cent. alcohol alone, and the necessary amount of sodium amalgam added. After some time an insoluble crystalline product will have formed if piperitone be present; this can be filtered off, purified from boiling alcohol, and the melting point determined.

For quantitative determination the method of Burgess (Analyst, March, 1904) can be applied, as the reaction with piperitone goes quite smoothly, using a 35 per cent. solution of neutral sodium sulphite. 5 c.c. of the oil are introduced into a 200 c.c. flask, with the neck graduated in  $\frac{1}{10}$  of a c.c. The sodium sulphite solution is then added, together with two or three drops of ordinary phenolphthalein solution; the flask is then placed in a boiling water bath and thoroughly shaken. The red colour formed is neutralised with a 10 per cent. solution of acetic acid, and the process repeated until the formation of the red colour does not take place on further heating. The unabsorbed oil is then lifted into the neck and read off when cold; the difference between that amount and the 5 c.c. taken gives the quantity absorbed, and this, multiplied by 20, the percentage of piperitone.

It is hardly likely that Eucalyptus oils other than that of *E. dives* will be employed for the commercial production of piperitone, and as the fractionation can be readily carried out, the commercial article should not contain less than 90 per cent. of that ketone.



## The Phenols of Eucalyptus Oils.

PRACTICALLY all crude Eucalyptus oils contain phenols, more particularly if the original distillations have been at all extended.

The actual amount in the oils of most species is, however, very small, and consequently phenols are not usually found in Eucalyptus oils of commerce, for the reason that these have in most cases been rectified by steam distillation before placing on the market, or else the original distillations have not been continued for a sufficiently long period.

The greatest quantity of crude phenols we have yet obtained from the oil of any species of Eucalyptus was 2 per cent., from that of *E. Risdoni*. In most species, however, the amount does not exceed 0.5 per cent., whilst in some of them probably less than  $\frac{1}{10}$  of that small quantity is present.

Two phenols are found in Eucalyptus oils, one of which is now described for the first time. They have been named TASMANOL and AUSTRALOL. The former of these is liquid and occurs in greatest amount in the cineol-phellandrene Eucalyptus oils derived from such species as *E. linearis*, *E. Risdoni*, &c. Its presence is indicated by the very red colour of these crude oils when they have been distilled from iron vessels. This group of trees is more extensively developed in Tasmania than in Australia, and for that reason the name tasmanol was chosen for the liquid phenol.

Australol is a beautifully crystallised phenol and occurs in greatest amount in the oils of the typical "Boxes," as *E. hemiphloia*, *E. Woollsiana*, &c. It is also present in the more pronounced cineol oils, derived from species of the "Gum" group. These two Eucalyptus groups (the "Gums" and the "Boxes") are extensively developed on the mainland of Australia, whilst the "Boxes" do not occur in Tasmania. The name australol has thus been chosen for the crystallised phenol, as it is principally derived from the oils of the mainland species.

Our experience indicates that both these phenols occur together, one or the other predominating in the oils of species belonging to certain groups. They may thus be somewhat closely related bodies.

It seems highly probable that the yellow colour of certain rectified cineol-bearing Eucalyptus oils is due to the influence of the crystallised phenol, particularly as it is more pronounced in those species yielding yellow-tinted oils, and when gently oxidised becomes of a bright yellow colour. This is particularly noticeable when the alcoholic solution is treated with ferric chloride.

Eucalyptus oils in which tasmanol is the pronounced phenol are water-white when rectified, this being traceable, perhaps, to the presence of the methoxy group in tasmanol, as australol has not this grouping. Eucalyptus oils containing over 70 per cent. of cineol thus occur in two forms—(a) the water-white oil from *E. Australiana*, and (b) the yellow-tinted oils from such Eucalypts as *E. polybractea*, *E. globulus*, &c.

The announcement of the occurrence of phenols in Eucalyptus oils was made by Professor R. Robinson and one of us, in a paper published by the Royal Society of New South Wales, in January, 1915. The paper deals with tasmanol, but also mentions the occurrence of a second phenolic body. Professor Robinson now resides in England, so that the further investigation of these phenols has devolved upon us.

The phenols were removed from the crude oils in the usual manner by shaking with dilute aqueous sodium hydrate, washing the aqueous solution with ether to remove adhering oil, acidifying and extracting with ether. The residue, which

contains small amounts of acetic and butyric acids, was washed with dilute sodium bicarbonate, extracted with ether, the ether removed, and the phenols distilled.

The product from the oil of *E. linearis* was utilised for the earlier determination of tasmanol, whilst that for the later investigation was obtained from the oil of *E. Risdoni*.

For the work on australol the oil of *E. hemiphloia* was utilised.

#### TASMANOL.

This is a liquid phenol, but little coloured when prepared in as pure a condition as was possible, but it darkened somewhat on keeping. The product from *E. linearis* had specific gravity at 23° C. = 1.077; refractive index at 22° = 1.5269, and was optically inactive. Its boiling-point under atmospheric pressure was 268–273° C. (uncorr.), and at 175° C. under 25 mm. pressure. It contained one methoxy group. The phenol was soluble in ammonia, partly so in sodium carbonate, but not in bicarbonate. It dissolved slightly in boiling water.

The tasmanol from *E. Risdoni* had specific gravity at 20° C. = 1.0809; refractive index at 20° = 1.5241, and was optically inactive. Its boiling point was 164° C. at 12 millimetres pressure. The phthalein fusion gave a light orange colour similar to that for australol, but of no distinctive value.

The reaction with ferric chloride in alcoholic solution is characteristic, and the deep blood-red colour which is at first formed remains persistent for days after the alcohol has evaporated, even becoming more crimson on standing.

The odour reminds one somewhat of carvacrol under certain conditions, but is more aromatic.

#### AUSTRALOL.

This crystallised phenol could be best prepared from the oils of the typical "Boxes," such as *E. hemiphloia*, *E. Woollsiana*, &c. We utilised the former of these species because it grows plentifully in the immediate neighbourhood of Sydney.

The phenolic bodies were first prepared in the manner described above, and afterwards distilled under reduced pressure. As australol boils at a considerably lower temperature than tasmanol it was not difficult to obtain the phenol fairly pure by fractionation under reduced pressure.

Australol boils at 115–116° C. under 10 millimetres pressure, and shows a tendency to remain for a long time in the liquid condition; if, however, the minutest particle of crystal is added, the whole mass instantly solidifies.

The specific gravity at 20° C. was 0.9971; refractive index at the same temperature = 1.5195, and was optically inactive. The phenol was best purified from solution in xylene, as it crystallised well from that solvent. It remained more or less as a varnish when dissolved in alcohol, chloroform, acetone and the usual organic solvents. The long thin prism crystals (enlarged 45 diameters), as crystallised from xylene, are well shown in the accompanying photograph. They exhibit the peculiarity of rounded ends to the prisms.

The phenol sublimes splendidly, and is unaltered by this treatment; it was thus possible to obtain it quite pure. It was soluble in ammonia, but not in sodium carbonate or bicarbonate.

Australol melts at 62° C., and has a tendency to remain in the super-fused condition for some time if not seeded. It forms a benzoyl compound which melts at 72–73°, when crystallised from petroleum ether.

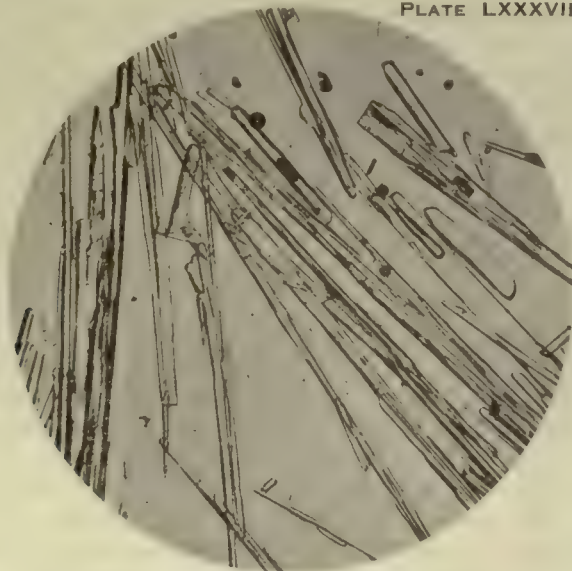
In alcoholic solution ferric chloride gives a fleeting greenish yellow colour at first, quickly changing to bright yellow. The phthalein fusion gives an



orange-coloured solution, of little distinctive value. Concentrated sulphuric acid gives no colouration, but nitric acid forms an orange-coloured compound.

Australol has an odour reminding one of ordinary phenol, and is very caustic, destroying the skin in exactly the same manner as does phenol. It is also very volatile, and if allowed to remain in the air soon entirely volatilises. It is an unsaturated phenol giving a liquid bromide.

PLATE LXXXVII



AUSTRALOL.

The crystallised phenol of Eucalyptus Oils.  $\times 45$ .

The formula is  $C_9H_{12}O$ , as indicated from the following analyses :—

(a) From the crystallised phenol :—

0.1589 gram. gave 0.4589 gram.  $CO_2$  and 0.1288 gram.  $H_2O$ .  
C. = 78.7, and H = 9.0 per cent.

(b) From the sublimed phenol :—

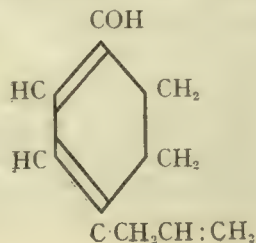
0.1386 gram. gave 0.4004 gram.  $CO_2$  and 0.1114 gram.  $H_2O$ .  
C. = 78.8 and H. = 8.93 per cent.

$C_9H_{12}O$  requires 79.4 per cent. C. and 8.82 per cent. H.

A molecular weight determination by the cryoscopic method, using benzene as solvent, gave 142.

The refractive index, as previously stated, was 1.5195 at  $20^\circ C$ . The molecular refraction calculated from this for a  $C_9H_{12}O$  molecule with three double bonds is 41.74; found 41.50. The phenol is unsaturated and evidently one double bond is in the side chain; this, most probably, has the allyl grouping, as it formed no colour reaction with picric acid. Two double bonds thus occur in the nucleus.

Australol thus appears to be dihydro-*p*-allylphenol, and to have the following probable molecular structure ;—





## The Free Volatile Acid of Eucalyptus Oils.

FREE acids usually occur in Eucalyptus oils, and in some of them it is present in sufficient amount to attack the iron of the still when the leaves are undergoing the process of distillation. The reason why such a large number of crude Eucalyptus oils have a reddish colour when distilled from iron vessels is because the free acid has dissolved away a portion of the metallic fittings of the still, the iron thus removed reacting upon the phenol tasmanol present in the oil. That this is so, is demonstrated by the fact that the majority of these deeply coloured oils can be rendered almost colourless by agitating with a solution of aqueous potash or soda, and if the coloured precipitate thus obtained be tested it will be found to consist largely of ferric oxide, providing of course, that copper fittings had not been used in the construction of the still, when the product would be tinted green. Under *E. cinerea* it has been shown that much copper was dissolved away during distillation, as copper still-heads had been employed. It has now become customary in Australia to discard copper fittings to the stills for Eucalyptus oil distillation.

The pinene-cineol oils usually contain the greatest amount of free acid, but with those of the more pronounced phellandrene-bearing species, like *E. dives*, *E. Delegatensis*, *E. vitrea*, &c., it is only present in comparatively small amount, consequently the crude oils of those species are usually but little coloured, although the phenol tasmanol also occurs in them to a small extent.

It was thought desirable to determine the free acid occurring in Eucalyptus oils, and for this purpose the following species were chosen, which may be considered as fairly representative of the several groups. From the study of these it was possible to form an opinion as to the general identity of the free volatile acid in Eucalyptus oils:

1. *E. Smithii*, a rich cineol-pinene oil, which contains but a small amount of esters, or free acid.
2. *E. cinerea*, a rich cineol oil, but which contains a comparatively large amount of both ester and free acid.
3. *E. phellandra*, representing an intermediate oil between those of the cineol-pinene group and the more pronounced phellandrene oils.

Through the kindness of the Australian Eucalyptus Oil Company, Sydney, we were supplied with a quantity of the water first obtained when rectifying the oils of these three species by direct distillation.

The water employed for the determination of the free acid in the oil of *E. Smithii* was derived from the rectification of 500 lb. of crude oil of that species. It was found that 20 gram. of the water required 0.058 gram. sodium hydrate, equal to 0.435 per cent. calculated as acetic acid. The remaining water was neutralised, evaporated to a small bulk, dilute sulphuric acid added and distilled until the whole of the volatile acids had come over. The distillate was then exactly neutralised with barium hydrate solution, evaporated to dryness, and the combined acid determined in the usual way by changing the barium salt into barium sulphate. 0.4344 gram. gave 0.3967 gram. barium sulphate, equal to 91.32 per cent. Theory requires 91.37 per cent.  $\text{BaSO}_4$ , so that it is evident that only acetic acid could have been present in the first distillate derived from the oil of this species.

The amount of free acid in the water obtained on rectifying the oil of *E. cinerea* by direct distillation was 2.1 per cent. considered as acetic (see under that species). The barium salt was prepared with the volatile acid similarly with that of *E. Smithii*. 0.9784 gram. of the barium salt on ignition with sulphuric acid gave 0.8930 gram. barium sulphate, equal to 91.27 per cent. Theory requires 91.37 per cent. barium sulphate, so that in this instance also, it seems probable that acetic acid could only have been present. It will be observed that the amount of free volatile acid in this case was about five times as much as in the distillate from *E. Smithii*.

In the water obtained on rectifying the oil of *E. phellandra*, 0.744 per cent. of free acid was present, calculated as acetic. The barium salt was prepared in the same manner as with the above two species. 0.5265 gram. of the barium salt when ignited with sulphuric acid gave 0.4804 gram. of barium sulphate, equal to 91.25 per cent., so that it is apparent that practically only free acetic acid could have been present as free acid in this oil also. The remainder of the acid distillate was neutralised with soda, and the soda salt crystallised out. Exhibits of pure sodium acetate in each instance were similarly prepared.

As concordant duplicate results were obtained in each case, it is evident that not more than mere traces of other volatile acids than acetic, could have been present in the oils tested, and as the species chosen were fairly representative of the whole genus, it is assumed that acetic is the free acid in the greater number of freshly distilled Eucalyptus oils.

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## The Butyl Ester of Butyric Acid in Eucalyptus Oils.

A low boiling ester, with a low refractive index, occurs in some quantity in the oil of *E. Perriniana*, is characteristic of this species whether growing in Tasmania or New South Wales, and is one of the distinguishing features between this species and *E. Gunnii*. Considerable work has been done on the oils of these species, distilled from material collected at both localities, and from this data, supported by botanical evidence, it is apparent that these two Eucalypts cannot be considered as identical species.

This ester is evidently a constant constituent in the oils of the members of a certain class of Eucalypts, although in most cases it occurs but in small amount. It is another instance of the peculiarity, so pronounced with chemical constituents in the genus Eucalyptus, by which is shown a progressive increase throughout a whole series of closely agreeing forms, the maximum being reached in one or more of them. Not only is this the case with the oils, but the various exudations and secretions also show a sequence, often running through the whole group, and this progression is sometimes remarkably complete.

Butaldehyde is a very common constituent in Eucalyptus oils, and is also one of the constituents which give to unrectified oils of this group a somewhat objectionable odour. The formation of the ester might perhaps be accounted for by a rearrangement in the aldehydic grouping. Normal butyric acid has already been identified as occurring in small quantity in several Eucalyptus oils, this acid probably being derived from the natural hydrolysis of the ester. A corresponding change takes place when the oil of *E. Perriniana* has been stored for a sufficiently long time.



The material of *E. Perriniana* from which the oil was distilled, was collected in September at Tingiringi Mountain, a locality in South-eastern New South Wales. The crude oil was rich in cineol, but phellandrene was not detected at this time of the year. The general characters agreed with those of the oil distilled from material of the same species collected at Strickland, in Tasmania.

The abnormally low refractive index of the lower boiling fractions led to the identification of this ester, because a refractive index, 1.4519 at 20° in ordinary fractions, had not previously been detected in Eucalyptus oils. The first notification of this ester was published by one of us in the Proc. Roy. Soc., N.S.W., December, 1914.

#### EXPERIMENTAL.

**The Acid.**—The crude oil (200 c.c.) of *E. Perriniana* was distilled, and the portion which came over below 190° C. boiled with aqueous potash under a reflex condenser for some hours. The aqueous portion was separated and distilled, but nothing came over below the boiling point of water, so that methyl, ethyl, and propyl alcohols were absent. The remainder was evaporated to dryness and the potassium salt decomposed by sulphuric acid and distilled until all the volatile acids had come over. The distillate had an odour of butyric acid strongly marked. The free acid was exactly neutralised with barium hydrate solution, evaporated to dryness and heated in the air-bath to 105° C. A molecular weight determination with the thus prepared barium salt gave the following:—

0.3592 gram. gave 0.2668 gram.  $\text{BaSO}_4$  = 74.28 per cent.

Barium butyrate forms, theoretically, 74.91 per cent.  $\text{BaSO}_4$ , so that butyric was probably the only volatile acid present. The odour and other indications suggested the normal form for this acid, and the ethyl ester prepared with it gave the characteristic pineapple odour. To decide the point the calcium salt was prepared by decomposing the remainder of the barium salt with sulphuric acid, distilling over the volatile acid, exactly neutralising with freshly prepared and filtered lime water, using a trace of phenolphthalein as indicator, and evaporating to a small bulk on the water bath until a portion of the solid salt separated; this dissolved again, however, when the liquid cooled. The solution was transferred to a test-tube and again heated, when the precipitate again formed, but dissolved on cooling. This peculiarity of the calcium salt indicates that the acid of this ester is normal butyric.

**The Alcohol.**—The oil after saponification, was separated and distilled, when about 2 per cent. came over below 150° C. A trace of cineol was present and most probably a trace of pinene also. This portion was carefully oxidised with  $\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4$ , heated to boiling, and allowed to stand for 24 hours. A volatile acid with the odour of butyric was readily detected. This was distilled over, exactly neutralised with barium hydrate solution, and evaporated to dryness and heated in the air oven. The barium salt thus obtained was identical in odour and gave reactions similar to that from the acid of the ester. Although the amount of the available salt was but small, yet, there was sufficient to enable a quantitative determination for molecular weight to be made.

0.0354 gram. gave 0.0264 gram.  $\text{BaSO}_4$  = 74.58 per cent.

Barium butyrate gives 74.91 per cent.  $\text{BaSO}_4$ .

As the ester is thus shown to be butyl-butyrate it might be assumed that both the alcohol and the acid are identical in form. Sufficient acid from the



alcohol was not available with which to prepare the calcium salt, but its odour, as well as that of its ethyl ester, was identical with those prepared with the acid of the ester, and also corresponded with similar substances made with pure normal butyric acid.

The greater portion of the total esters in the oil of *E. Perriniana* appears to be the low boiling butyl-butyrate; this is shown from the saponification results with the freshly distilled oil. The saponification number for the crude oil was 52.6, representing 13.52 per cent. of an ester having a molecular weight 144. The saponification number for the portion distilling below 190° C. (75 per cent.) was 57.2, representing 14.7 per cent. of ester in this fraction. The ester was not decomposed on direct distillation, as no free acid was detected in the lower boiling fractions.

It might be well in future analyses of Eucalyptus oils, distilled from trees belonging to this group, to determine the saponification number for the ester in the lower boiling fraction, particularly when the ester value for the crude oil is at all high.

On the completion of the work on the ester in the oil of *E. Perriniana* from New South Wales, one naturally returned to the oil of this species previously distilled from Tasmanian trees, the fractions of which had been preserved. The first fraction, representing 18 per cent. of the crude oil, distilling below 173° C., contained a little free acid formed by the natural hydrolysis of a portion of the ester. The saponification number for the ester and free acid in this fraction was 45.8. This result shows the ester in the oil of *E. Perriniana* of Tasmania to be a low boiling one, and also that the greater portion distilled over in the first fraction, as was the case with the oil of the New South Wales material.

## The Valeric Acid Ester occurring in some Eucalyptus Oils.

It has been shown (see tabulated list) that esters, either in large or small amounts, occur in all Eucalyptus oils, varying from 60 to 77 per cent. of geranyl acetate, in the oil of *E. Macarthuri*, to very minute quantities in such oils as *E. dives*, *E. radiata*, *E. Smithii*, &c. The amyl-ester of eudesmic acid occurs in some quantity in the oil of *E. aggregata*, and in the oil of *E. carnea* an acetic acid ester has been determined (see under that species). Butyl-butyrate is also a frequent ester in Eucalyptus oils of a certain class. The constituents of these four esters did not, however, explain the presence of a volatile acid resembling valeric acid, which constituent had often been detected in the oils of several species, and in those of *E. saligna* var. *pallidivalvis*, *E. cinerea*, *E. gonio-calyx*, *E. Maidenii*, *E. botryoides*, &c., the presence of a considerable amount of ester had been determined. The product of *E. saligna* var. *pallidivalvis* appeared to be the best for the determination of this valeric acid ester, because the acid was so well demonstrated, and the amount of ester in the oil comparatively large. 200 c.c. of the oil of this species, collected at Lismore, New South Wales, in May, 1898, were boiled for some hours with aqueous potash, under a reflex

condenser. The oil was afterwards separated, and the alkaline portion distilled; nothing came over below  $100^{\circ}\text{C}$ ., so that alcohols boiling below that temperature were absent. The precipitate which had formed was filtered off and ignited; it was found to consist almost entirely of ferric oxide, which had evidently been derived from the iron digesters; and this acting on the phenols gave the deep red colour to the crude oil. The filtered solution, when evaporated to a small bulk, separated a dark substance which became semi-solid on cooling. On acidifying this with sulphuric acid, an acid was obtained which, on purification, gave crystals differing in no respect from eudesmic acid, previously obtained from the oil of *E. aggregata*. Amyl-eudesmate thus occurs in the oil of this species, and is probably a frequent constituent in Eucalyptus oils. The aqueous filtrate from the solid acid separated as above, was acidified with sulphuric acid, and repeatedly distilled until the whole of the volatile acids had been obtained. The distillate which had a strong odour of valeric acid, was neutralised with soda, and evaporated to dryness; the crystalline salt thus obtained, was decomposed with sulphuric acid, when an oily acid separated, having the objectionable odour of iso-valeric acid. The separated acids were recovered by agitating with ether and the ether removed. The product had the odour of, and gave the reaction for valeric acid, agreeing in this respect with those obtained with a sample of pure iso-valeric acid. The molecular value of the acid or acids thus obtained was determined in the ordinary way from the barium salt; 0.3328 gram. of the barium salt gave 0.2327 gram. of barium sulphate when ignited with sulphuric acid, equal to 69.92 per cent.  $\text{BaSO}_4$  or 41.08 per cent. of barium.  $\text{Ba}_2\text{C}_5\text{H}_9\text{O}_2$  contains 40.45 per cent. of barium, and gives 68.73 per cent. of barium sulphate. It is thus apparent that the volatile acids occurring as an ester in some Eucalyptus oils, and particularly in the oil of *E. saligna* var. *pallidavalvis* is principally valeric acid, and most probably the iso-form.

The oil recovered after saponification with aqueous potash was then distilled, in order to determine, if possible, what alcohols were present. It was certain that one of these was amyl alcohol, derived from the ester of eudesmic acid, and on acetylating the portion distilling between  $130^{\circ}\text{C}$ . and  $150^{\circ}\text{C}$ . amyl acetate was readily obtained. Below  $130^{\circ}\text{C}$ . only a few drops came over; but between  $130^{\circ}\text{C}$ . and  $150^{\circ}\text{C}$ . 7 per cent. distilled, while between  $155^{\circ}\text{C}$ . and  $160^{\circ}\text{C}$ . 66 per cent. distilled; this fraction was almost entirely dextropinene, and had specific gravity 0.868 at  $15^{\circ}\text{C}$ . The specific gravity of the fraction  $130^{\circ}\text{C}$ . and  $150^{\circ}\text{C}$ . was 0.850 at  $15^{\circ}\text{C}$ . What the alcohol is, if any, in the oil of this species besides amyl, we have not so far been able to determine, and further research is necessary to decide this question. Until this point is settled it would be difficult to calculate the actual percentage of ester in many Eucalyptus oils, particularly in cases when both the acetic acid ester and the valeric acid ester occur together. When the saponified oil was acetylated the saponification number was found to be 54.04, which, calculated as  $\text{CH}_3\text{COOC}_5\text{H}_{11}$  gives 12.55 per cent. The acetylated oil had a marked odour of amyl-acetate which was not masked by the terpenes present. That some free alcohol was also present in the oil of this species was shown by the saponification number of the original crude oil, including that of the free acid, being only 41.76.

It is, perhaps, worthy of remark that Eucalyptus oils which contain the valeric acid ester also show the presence of the corresponding aldehyde, and that crude cineol-pinene oils which have the most objectionable odour of volatile aldehydes, usually contain the valeric acid ester. From the results of these investigations it appears that the valeric acid in Eucalyptus oils occurs mostly as an ester and not in the free condition, because the free acid in Eucalyptus oils is acetic. (See the article dealing with the free volatile acid of Eucalyptus oils.)



## The Amyl Esters of Eucalyptus Oils.

ESTERS of the character of amyl-eudesmate and amyl-phenylacetate have, so far, only been found in a very few Eucalyptus oils. They appear to be present in greatest amount in that from *E. aggregata*, and it was from this species, collected at Fagan's Creek, near Braidwood, New South Wales, that oil was distilled in which amyl-eudesmate was first detected. (See paper by one of us, Proc. Roy Soc., N.S.W., 34, 1900, 72.) The yield of oil from *E. aggregata* is, unfortunately, almost the least of any, and consequently it was difficult to obtain sufficient oil for complete investigation.

In 1909 material of *E. aggregata* was forwarded from Rydal, New South Wales, many miles from the previous locality, but even less oil was distilled from this than from the Fagan's Creek leaves.

In 1920 we procured fresh material from Rydal, but were still more unfortunate, as oil did not distil in sufficient quantity to enable it to be collected, and attempts to extract the oil from the leaves directly with ether were not more satisfactory. We were desirous of obtaining the oil of this species in some quantity because the investigation of the Rydal material had resulted in the separation of a second solid acid which was different from eudesmic acid, and had the characters of phenylacetic acid. It is thus possible that two esters of amyl alcohol occur in the oil of this species, or else the Rydal trees are not quite identical with those growing at Fagan's Creek. The identity of the amyl-alcohol was, however, proved in the oils from both localities. When further investigation on the oil of this species and its esters is undertaken it would be well to procure material from both the above localities, and collected during the spring or early summer months, as at that period of the year the maximum amount of oil might be expected to occur. 400 lb. of leaves and terminal branchlets from Fagan's Creek gave only  $2\frac{1}{2}$  oz. of oil, equal to 0.04 per cent., while that from Rydal gave a yield of 0.038 per cent.

The saponification number for the Fagan's Creek oil was 112.2, and for the Rydal oil 119.5.

### DETERMINATION OF THE ALCOHOL.

A portion of the Fagan's Creek oil was boiled for several hours with aqueous potash under a reflux, and the solution then distilled. The aqueous distillate was surmounted by an oil which had the characteristic odour of amyl alcohol, as had also the aqueous portion itself. This gave the iodoform reaction, but as nothing distilled below the boiling-point of water it was apparent that none of the lower boiling alcohols was present. The separated oily layer commenced to distil at  $130^{\circ}$  C., and the portion which came over between that temperature and  $135^{\circ}$  was separated. This fraction had the odour of, and gave the reactions for amyl alcohol, and when oxidised with potassium bichromate and sulphuric acid in the usual way, formed valeric acid. The silver salt was prepared and on ignition this gave 51.74 per cent. silver, which is almost the theoretical amount for silver valerate. As almost identical results were obtained with the alcohol of the ester in the Rydal oil, it is evident that amyl alcohol is the alcohol of the esters in the oil of *E. aggregata*.

Amyl alcohol was detected in the oil of *E. globulus* by Bourchardat and Olivier [Bull. Soc. Chem. III, 9 (1893), 429], and iso-amyl alcohol is now known to occur in the oils of other species of Eucalyptus.



## DETERMINATION OF EUDESMIC ACID.

The crude oil from the Fagan's Creek material was fractionated, and the portion distilling between 245–292° C. treated with aqueous potash, the adhering oil removed by ether, and the alkaline solution acidified. The organic acid thus obtained separated in the crystalline condition. Although much of the ester had altered at the temperature to which it had been subjected, yet a large proportion distilled unchanged. This was saponified by alcoholic potash and the acid separated in the usual way. The residue boiling above 292° was treated in a similar manner, and the whole of the acid collected. It was purified by first boiling with animal charcoal in an alcoholic solution, again separated, and finally recrystallised two or three times from boiling water.

The acid as thus prepared was colourless, and melted at 160° C. In general appearance it somewhat resembled salicylic acid, and crystallised in rhombic needle prisms which polarised well. It was readily soluble in boiling water and in most organic solvents, but was sparingly soluble in cold water (1 part in 1,355 parts of water at 20°). The acid was unsaturated; sublimed with difficulty, apparently unchanged, and was exceedingly soluble in ammonia. The neutral ammonium salt gave an orange-coloured precipitate with ferric chloride, and a bluish-green precipitate with sulphate of copper. The silver salt was prepared from the ammonium salt, and this on ignition gave 33.86 and 33.83 per cent. of silver in two determinations, corresponding to a molecular weight 215. The analytical results for the acid indicated the  $C_{14}H_{18}O_2$  molecule, with molecular weight 218, so that eudesmic acid is considered to have that formula.

The name is derived from that given by Robert Brown to the genus—*i.e.*, *Eudesmia*.

## DETERMINATION OF PHENYLACETIC ACID.

The crude oil from the Rydal material was boiled for some hours with aqueous potash and the acid of the ester prepared in the usual way. When finally purified it was of a laminated structure and a paraffin-like nature, and melted at 76° C. When titrated with a deci-normal solution of sodium hydrate, the acid gave a molecular weight of 135.6, assuming it to be monobasic. It was a saturated acid, and when treated with manganese dioxide and sulphuric acid gave an odour of benzaldehyde. This evidence points to the acid of the ester being phenylacetic acid. In general appearance and chemical characters it differed from the corresponding acid obtained in a similar manner from the Fagan's Creek material.

The amyl esters occurring in the oil of *E. aggregata* are thus of particular scientific interest, and worthy of more complete investigation. It is unfortunate that the yield of oil from the species is so small, and the localities where it grows difficult of access.

## The Pinenes of Eucalyptus Oils.

DURING this research it has been demonstrated that both lævo- and dextro-rotatory pinenes occur in Eucalyptus oils in varying quantities, from the small amount found in the richer cineol yielding species, to those oils consisting almost entirely of either dextro- or lævo-rotatory pinene. From the leaves of some species an excellent oil of turpentine can be obtained, corresponding to either the American or European varieties, and it thus becomes difficult to determine whether or not a Eucalyptus oil has been sophisticated by the addition of commercial oil of turpentine. If the presence of pinene in quantity were proved, there is still no reason why the oil might not have been derived entirely from Eucalyptus leaves, and we presume that such a product from such a source must be Eucalyptus oil, even if it consists almost entirely of pinene, like those of *E. dextropinea*, *E. lævopinea*, *E. Wilkinsoniana*, and others. As these pinene oils necessarily fail to meet the present requirements of the British or American Pharmacopœias for Eucalyptus oils required for pharmaceutical purposes, they should be exploited in the direction of supplying commercial requirements for turpentine. Whether certain of the non-cineol-bearing Eucalyptus oils, or those containing but a small amount of that constituent, will eventually be used for medicinal purposes is a matter that has yet to be decided.

It has been shown in a previous article that the almost transverse parallel venation of Eucalyptus leaves, like those of *E. calophylla*, *E. corymbosa*, *E. saligna*, *E. botryoides*, &c., is an indication of the presence of a predominance of pinene in their oils, and it was the recognition of this constantly occurring constituent in this group that enabled this peculiarity in the oils of species with this leaf venation to be noted. In all Eucalyptus oils that are rich in cineol, pinene occurs, although in some of them it is present in only small amount. From oils of numerous species it has been isolated and its identity proved by chemical methods, as shown with the pinene which occurs in the oils of *E. saligna*, *E. robusta*, &c. From the results thus obtained it is apparent that the pinenes obtainable from the oils of the Genus Eucalyptus (N.O. Myrtaceæ) are chemically identical with those obtainable from the Genus Pinus (N.O. Coniferæ.). In the oils of Eucalyptus species that connect the large group of "Boxes" with the "Gums," as *E. conica*, *E. Bosistoana*, *E. quadrangulata*, *E. propinqua*, and others, the presence of pinene is pronounced, as might be expected from their closer proximity to the pinene group, and consequently these oils are on the border line which separates oils capable of passing the present standard, from those lower in this respect. The oils of the species belonging to this group all contain a fair amount of cineol, and the terpene phellandrene is entirely absent, or at the most only present in traces in rare instances. The predominant pinene in these oils is invariably the dextro-rotatory one, and this is also true for oils belonging to the richer cineol class, but often the pinene of opposite rotation is present in such amount as to cause the oil to be almost inactive, and yet for it to be poor in cineol; for this reason the value of the test of optical rotation for Eucalyptus oils is limited in value, as it may be misleading. If the pinene found in Eucalyptus oils always rotated the ray in the same direction the test would be of greater value, but this is not the case, and in this respect the pinene differs from the phellandrene which appears always to be lævo-rotatory in Eucalyptus oils.

By the discovery of the pinene yielding oils, such as those of *E. dextropinea* and *E. lævopinea*, it has been possible to investigate somewhat completely the properties of the Eucalyptus pinenes. (See paper Proc. Roy. Soc., N.S.W.,



xxxii, 195.) From this investigation it was possible to show the differences, chemically, between *E. laevopinea* and *E. macrorhyncha*, because the oil of the former does not contain eudesmol and other constituents which occur in the oil of *E. macrorhyncha*. These chemical differences are supported in another direction, as the leaves of *E. laevopinea* do not contain myrticolorin, which dye-material occurs in such abundance in the leaves of *E. macrorhyncha*. The laevo-rotatory pinene in the oil of *E. phlebophylla* is also sufficient to discriminate that species from *E. coreacea*, although morphologically these two species show great similarity. By similar means it is easy to determine the difference between *E. dextropinea* and *E. pilularis*, as the oil of the latter species is always strongly laevo-rotatory in its lower boiling portion, and also contains phellandrene, which terpene is absent in the oil of *E. dextropinea*.

The material for the original investigation was obtained from (1) Barber's Creek (now Tallong); (2) Currawang Creek (near Braidwood); and (3) Nullo Mountain (near Rylstone), all in New South Wales. The material from Barber's Creek, from which the dextro-rotatory pinene was obtained, was botanically identical with that of the species from Currawang Creek, and the results of the determinations of the oils from those localities (over 100 miles apart) indicate that the oils had been distilled from similar material, again emphasising the fact of the comparative constancy of chemical constituents in the oils of identical species. The Rylstone material was quite distinct, and gave an oil also consisting of pinene, but having even a greater rotation to the left than had the pinene of the other species to the right. It was a piece of good fortune to have obtained the material of *E. dextropinea* and *E. laevopinea* at the same time, so that their pinenes could be worked out together.

The presence of pinene in the oil from *E. globulus* was detected some time ago. M. Cloëz, in 1870,\* published the first detailed observations relative to the oil of *E. globulus*. This research is now of historic interest, from the fact that he obtained a hydrocarbon  $C_{10}H_{16}$  boiling at  $165^{\circ} \text{C.}$ , by distilling his so-called eucalyptol with  $P_2O_5$ . This terpene he called eucalyptene. Afterwards Faust and Homeyer† gave the same name to a terpene from Eucalyptus oil, which, according to them, was a terebenthene, being readily polymerised by sulphuric acid. Later, Wallach and Gildemeister‡ stated that the hydrocarbon, eucalyptene, from *E. globulus*, is identical with dextropinene.

In 1895 Bourchardat and Tardy§ carried out experiments with the hydrocarbon found occurring in small quantity in the oil of *E. globulus*, and arrived at the conclusion that it had the properties of the laevo-rotatory terebenthene found in French oil of turpentine, but with an almost equal opposite rotation. They gave its boiling point as  $156-157^{\circ} \text{C.}$ ; its density as 0.870 at  $0^{\circ} \text{C.}$  and 0.865 at  $18^{\circ} \text{C.}$ , and its specific rotation at  $15^{\circ} \text{C.}$  as  $[a]_D + 39^{\circ} \text{C.}$  They gave Riban's determination|| for the specific rotation of laevo-rotatory terebenthene as  $-40.3^{\circ}$ . It appears, therefore, from the results obtained by these authors on this hydrocarbon from the oil of *E. globulus*, and those obtained in this research on the same hydrocarbon from the oil from *E. dextropinea*, that these dextro-rotatory pinenes obtainable from members of two distinct groups of Eucalypts are identical bodies, and that the dextro-rotatory pinene from the whole Genus Eucalyptus is a physical isomeride of the laevo-rotatory pinene (terbenthene) obtained from French oil of turpentine,

\* Compt. Rend., 1870, 687, and Journ. de Pharm. et de Chemie, 1870, xii, 201.

† Ber. 7, 63, 1429.

‡ Ann. 246, 265-284. Abst. Chem. Soc., 1888, 54, 1205.

§ Compt. Rend., 1895, 120, 1417-1420.

|| Compt. Rend., 78, 788; 79, 314.



and also of the lævo-rotatory pinene of the Eucalypts, although this lævo form has, as far as observed, a higher specific rotation.

Although it had been assumed that pinenes having right and left rotations were probably present in Eucalyptus oils, yet no proof had previously been forthcoming that this was so. The isolation of the corresponding lævo-rotatory pinene from the oil of *E. lavopinea*, *E. Wilkinsoniana*, and other species shows conclusively that such is the case, and that we have existing in the oils of the Eucalypts two pinenes, one of which is the physical isomeride of the other. In this respect the oils of the Eucalypts differ from those of the Angophoras.

The two species of Eucalypts here selected, from which these highly rotatory pinenes were obtained, are members of a different group from that to which *E. globulus*, *E. Bridgesiana*, &c., belong. The study of the oils of the "Stringybark" group has been of great assistance in helping to extend the knowledge of the constituents of the oils of the Genus.

Cineol is present in very small amount in the oils of these two species, being rather more pronounced in that of *E. lavopinea*, and it was only possible to detect it with certainty in the portion of the oil distilling at the right temperature. It is not thought that at any time of the year will cineol be found to be much more in evidence, and a determination for cineol by the resorcinol method in the oil of *E. dextropinea* only gave a return of 6 per cent. in the crude oil.

The Currawang Creek sample of *E. dextropinea* gave 63 per cent., boiling between 156 and 162° C., and 25 per cent. more distilling between 162 and 172° C. The oil from the Barber's Creek sample, under exactly the same conditions, gave 62 per cent., boiling between 156 and 162° C., and 25 per cent. more between 162 and 172° C. Further investigation showed these two oils to be practically identical, although the Barber's Creek sample was rather more highly dextro-rotatory than that from Currawang Creek, but differences of this character might be expected, because experiments have shown that oils obtained from trees of the same species growing together under exactly similar conditions, have not the same rotations, but differ at times to the extent of a few degrees. Constancy in optical rotation is not observed with Eucalyptus oils, although the variation as a rule only extends to a few degrees.

The oil from the Rylstone Eucalypt, rectified under exactly similar conditions, gave 60 per cent., distilling between 157 and 164° C., and 28 per cent. more between 164 and 172° C., so that the temperature required to distil the lævo-rotatory pinene was slightly higher than that necessary to distil the dextro-rotatory form. The higher boiling point was, however, traceable to the rather larger amount of cineol in the oil of *E. lavopinea*.

**The dextro-rotatory pinene.**—The crude oil of *E. dextropinea*, from Currawang Creek, gave the following results:—

On rectification, 2 per cent. came over below 156° C., this portion contained a little acid water and a small quantity of volatile aldehydes.

Continuing the distillation:—

|                   |                               |                      |
|-------------------|-------------------------------|----------------------|
| 63 per cent.      | distilled between 156–162° C. | = first fraction.    |
| 25                | " " " 162–172° C.             | = second fraction.   |
| Specific gravity, | first fraction, at 15° C.     | = 0.8670.            |
| " "               | second fraction "             | = 0.8725.            |
| " "               | crude oil "                   | = 0.8758.            |
| Optical rotation, | first fraction "              | $a_D + 33.1^\circ$ . |
| " "               | second fraction "             | $a_D + 31.7^\circ$ . |

The crude oil from *E. dextropinea*, from Barber's Creek, gave the following results :—

On rectification 2 per cent. came over below 156° C.

Continuing the distillation :—

|                   |                               |                       |
|-------------------|-------------------------------|-----------------------|
| 62 per cent.      | distilled between 156–162° C. | = first fraction.     |
| 25                | “ “ 162–172° C.               | = second fraction.    |
| Specific gravity, | first fraction, at 15° C.     | = 0.8691.             |
| “                 | second fraction “             | = 0.8759.             |
| “                 | crude oil “                   | = 0.8778.             |
| Optical rotation, | first fraction “              | $a_D + 34.4^\circ$ .  |
| “                 | second fraction “             | $a_D + 32.46^\circ$ . |

It is thus apparent that the two samples might be considered as identical oils, only varying to the extent usually found with those of the same species of *Eucalyptus* at the same time of the year. Further investigation was, therefore, continued on the oil from the Barber's Creek sample alone. On redistilling the portion boiling between 156° and 162° C. the following results were obtained :—

|                   |                               |                       |
|-------------------|-------------------------------|-----------------------|
| 28 per cent.      | distilled between 156–157° C. | = first fraction.     |
| 30                | “ “ 157–158° C.               | = second fraction.    |
| 23                | “ “ 158–160° C.               | = third fraction.     |
| Specific gravity, | first fraction, at 15° C.     | = 0.8654.             |
| “                 | second fraction “             | = 0.8666.             |
| “                 | third fraction “              | = 0.8682.             |
| Optical rotation, | first fraction “              | $a_D + 34.98^\circ$ . |
| “                 | second fraction “             | $a_D + 34.73^\circ$ . |
| “                 | third fraction “              | $a_D + 33.88^\circ$ . |

The third and final rectification, taking the portion distilling between 156–158° C., gave 50 per cent. boiling between 156 and 157° C. This fraction gave the following results :—

|                                            |           |
|--------------------------------------------|-----------|
| Specific gravity at $\frac{4}{4}^\circ$ C. | = 0.8750. |
| “ $\frac{18}{16}^\circ$ C.                 | = 0.8629. |

By taking the specific gravity obtained at 18° C., the specific rotation was  $[a]_D + 41.2^\circ$ . The refractive index at 20° C. for a specially prepared sample was 1.4661.

A sample of commercial dextro-rotatory oil of turpentine, rectified in the same apparatus, under exactly similar conditions, and using the same corrections, gave 35 per cent. distilling between 156 and 157° C. This fraction had specific gravity at 20° C. = 0.8624, and a specific rotation  $[a]_D + 13.8^\circ$ .

**The Lævo-rotatory Pinene.**—The crude oil of *E. lævopinea*, from Rylstone, N.S.W., distilled a few days after collection, gave the following results :—

On rectification 2 per cent. came over below 157° C., this portion contained the usual amount of acid water and some volatile aldehydes.

Continuing the distillation :—

|                   |                               |                       |
|-------------------|-------------------------------|-----------------------|
| 60 per cent.      | distilled between 157–164° C. | = first fraction.     |
| 28                | “ “ 164–172° C.               | = second fraction.    |
| Specific gravity, | first fraction, at 15° C.     | = 0.8701.             |
| “                 | second fraction “             | = 0.8747.             |
| “                 | crude oil “                   | = 0.8754.             |
| Optical rotation, | first fraction “              | $a_D - 40.67^\circ$ . |
| “                 | second fraction “             | $a_D - 38.75^\circ$ . |



On again distilling that portion which came over between 157 and 164° C., the following results were obtained :—

|                                              |                    |
|----------------------------------------------|--------------------|
| 42 per cent. distilled between 157–160° C.   | = first fraction.  |
| 35       "       "       "       160–164° C. | = second fraction. |
| Specific gravity, first fraction, at 15° C.  | = 0.8660.          |
| second fraction       "                      | = 0.8671.          |
| Optical rotation, first fraction       "     | $a_D$ — 42.44°.    |
| second fraction       "                      | $a_D$ — 41.08°.    |

The third and final rectification, again taking the first fraction, gave 50 per cent. of an oil boiling between 157 and 158° C. This gave results as follows :—

Specific gravity at  $\frac{4}{4}$ ° C. = 0.8755.  
                                $\frac{19}{16}$ ° C. = 0.8626.

Specific rotation taking density at 19° C. =  $[a]_D$  — 48.63°. The refractive index at 20° C. for a specially prepared sample was 1.4660.

The boiling-point of this lævo-rotatory pinene was thus a shade higher than the dextro-rotatory form; this was shown to be due to the presence of a trace of cineol still remaining,

The same apparatus was employed for the whole of the distillations, and the results were obtained under exactly similar conditions, and upon a similar quantity of oil.

From the above results it will be seen that the several fractions of the two oils gave fairly concordant results, with the exception that the oil from *E. lævopinea* boiled at a slightly higher temperature than that from *E. dextropinea*. Another sample was then prepared and the cineol removed by shaking with 50 per cent. resorcinol; the remaining pinene boiled at 156° C., the same as that from *E. dextropinea*. The difference between the Eucalyptus pinenes is in their extreme opposite rotations, and while the specific rotation of the dextro-rotatory form is twice as great as that observed in the pinene from dextro-rotatory oil of turpentine, the specific rotation of the lævo-rotatory form is greater than that of the pinene from lævo-rotatory oil of turpentine.

The pinene from *E. lævopinea* does not, however, show the highest specific rotation to the left. This was given by the pinene from *E. phlebophylla*; a sample of the pure pinene from that species having a specific rotation  $[a]_D$  — 50.18°. This oil was distilled in August, 1919, from material collected at Braidwood, New South Wales.

The Eucalyptus pinenes are identical in appearance, being colourless, mobile liquids, and have a similar odour and other resemblances to the pinene from ordinary oil of turpentine; the odour was, perhaps, more distinctly shown with the dextro-rotatory form.

**The nitrosochlorides.**—For the preparation of these compounds one volume of the pinene was added to one of amyl nitrite, and the mixture dissolved in two volumes of glacial acetic acid; this was cooled in a mixture of ice and salt, and concentrated hydrochloric acid and glacial acetic acid, in equal parts, slowly added while the blue colour remained; it was then allowed to crystallise in the freezing mixture. The crystals from both forms were identical in every respect and melted quite sharply at 103–104° C. The product from the dextro-pinene was heated with alcoholic soda, and the nitrosoterpene thus formed, when crystallised from alcohol, melted at 128–129° C.

**The hydrates.**—About 4 or 5 volumes of the pinenes were frequently agitated for two or three days with 1 volume of nitric acid (specific gravity 1.25) and half its quantity of alcohol; the solutions were then allowed to slowly evaporate in



open vessels. After some days crystals were formed in some quantity with both forms. These were rhombic crystals, and when purified by recrystallisation from alcohol, melted at 116–117° C. with elimination of water. On melting these terpin hydrates and taking the melting point of the terpins thus formed, it was found that both melted at 102–103° C., and readily sublimed. The terpin hydrate from either form was soluble in boiling water, in alcohol, and in ether, and behaved chemically in exactly the same manner in every respect.

A vapour density determination of the pinene gave almost the identical figures required for the molecule  $C_{10}H_{16}$ .

The monohydrochloride was prepared with the dextropinene; this had the odour and appearance of ordinary camphor and melted at 123–124° C.

Crystalline bromides were not obtained by ordinary methods.

For the corresponding pinene from the oils of the closely-related genus *Angophora*, see paper by one of us, Proc. Roy. Soc., N.S.W., August, 1913.

## The Eucalyptus Oils Yielding Pinene for Turpentine Production.

DURING the systematic investigation of the various Eucalyptus oils recorded in this work, it was found that pinene is a most pronounced constituent in certain species, the greater portion of several of them consisting of that terpene.

The species from which it is possible to distil an oil similar in character and composition to ordinary "turpentine" were, at the time of their investigation, scientifically undescribed, and in order to distinguish the two principal pinene yielding species, it was decided to apply the names *E. dextropinea* and *E. lævopinea* to them respectively,\* so as to clearly indicate the location of either the dextro- or lævo-rotating pinene, and also to point out from which Eucalyptus species the two optically active forms of "turpentine" could be distilled. Other species, such as *E. phlebophylla* and *E. Wilkinsoniana*, might also be mentioned in this connection.

Coniferous trees from which an oleo-resinous exudation, suitable for "turpentine" production, could be derived, hardly occur in Australia, and it is only from one tree (*Agathus robusta*) the "Queensland Kauri," that it would be possible to prepare "turpentine" commercially.† The resinous latex of this tree contains about 14 per cent. of terpenes corresponding in composition to ordinary turpentine, but unfortunately the trees are too sparsely distributed and too few in number to enable an industry to be established in this way, even if other conditions did not operate adversely.

If it is desired, therefore, to produce Australian "turpentine" from indigenous trees, other sources of supply must be sought, and to this end we suggest the above species of Eucalyptus for this purpose. By the application of

\* In this naming of species on a chemical constituent we follow Smith in Trans. Linn. Soc., 111, 286 (partly), who, soon after the foundation of Australia, named the "Sydney Peppermint," *Eucalyptus piperita*, on account of certain constituents in the oil, as indicated by the odour.

† See Research on the Pines of Australia, Baker and Smith, p. 386. (Technical Education Series, No. 16.)

modern methods of scientific cultivation it might be possible to bring about increased production of oil in the leaves, and thus secure a greater yield of oil than is obtainable from the leaves of mature trees at the present time. The establishment of a "turpentine" distilling industry in Australia from the Eucalypts might thus be made possible. A point in its favour is that the crop of leaves would be constant and the trees not killed as obtains in America.

The sources of supply of commercial turpentine have for a long time been slowly decreasing, while the demand has, at the same time, risen greatly. The supply of "turpentine" in the United States is slowly being exhausted, and statistics show that the demand has increased over 90 per cent. during very recent years. The question is thus of considerable commercial importance, not only to Australia but to the world generally.

To meet this demand it should be possible to procure quickly and continually supplies from plants of the pinene yielding Eucalypts grown from seed, and systematically treated similarly to other crops. Probably four to five years would be ample to produce a sufficient growth of leaf, and the oil from this young material would agree in composition with that obtained from the leaves of older trees, while generally the yield would be greater. In comparison with the slow growth of Coniferous trees for "turpentine" production, the advantage is altogether with the Eucalypts.

Mature trees of *E. dextropinea* have already yielded us 1 per cent. of oil, over 90 per cent. of which corresponded to ordinary turpentine. The residues from the rectified oil would also be of value, particularly as a considerable proportion consists of geranyl-acetate and free geraniol.

Although it would hardly pay to undertake the manufacture of "turpentine" from mature trees of these two species, as they grow to a large size, yet, if they were cultivated it should be possible to produce turpentine cheaper than it is now being landed from America.

It appears, therefore, that it is to the Eucalypts that we must look to provide the necessary supplies of turpentine in the future. (See also the article on the Pinenes of Eucalyptus Oils.)

## Phellandrene in Eucalyptus Oils.

THIS terpene is somewhat extensively distributed in the oils of certain groups of Eucalypts, being more pronounced in those belonging to the more recent end of the genus, and to occur more abundantly in those species common to the Eastern and South-eastern portion of the Continent, and Tasmania.

It is a somewhat uncertain terpene, as it can only be detected in the oils of some species when these are distilled at particular times of the year, being apparently absent at other periods. This peculiarity is specially noticeable with those species which are apparently on the border line, as it were, of phellandrene production, as for instance with some of the "Boxes," and species closely associated with these.



The phellandrene in Eucalyptus oils has usually a high rotation to the left, so that the diminution, or otherwise, in the normal optical rotations of the crude oils of some species is traceable to the influence of this terpene, consequently the rotation constant is less stable with the phellandrene bearing Eucalyptus oils\* than with those in which the predominant terpene is pinene. This difference is more distinctly marked with the oils of those species in which dextro-rotatory pinene and lævo-rotatory phellandrene occur together in some quantity, and the instability of rotations of the phellandrene in these cases is distinctly noticeable. The influence of dextro-phellandrene is also shown in some of the more pronounced phellandrene oils at certain times of the year.

Unlike pinene, which occurs in both active forms, phellandrene in any Eucalyptus oil has not yet been found in which the dextro-rotatory modification predominates, although the great differences shown in the magnitude of rotations with the oils of the several species in which this terpene occurs, suggests the presence of both active forms. Lævo-phellandrene is thus the predominant form in Eucalyptus oils, and as practically all those of the phellandrene-bearing Eucalypts have now been investigated, it is hardly likely that the dextro-rotatory modification will now be found to be present in excess in the oils of this genus.

Phellandrene in Eucalyptus oils is often associated with lævo-rotatory piperitone, but not always, although it may be accepted that the most pronounced phellandrene Eucalyptus oils always contain this ketone in smaller or larger amounts, in ordinary distillates from 5 per cent. in that of *E. radiata*, to 40 per cent. in that of *E. dives*.

It is unnecessary to enumerate here those Eucalyptus species in the oils of which phellandrene has been detected, as they are somewhat numerous, but they will be found recorded in the table of general characters and principal constituents.

Phellandrene was isolated and named by Pesci in 1884 (Gazz. Chim. 16, 225), who obtained it from "Water fennel" oil (*Phellandrium aquaticum*). The terpene he prepared had specific gravity at 10° C. = 0.8558, and specific rotation  $[a]_D + 17.64^\circ$  (Heusler, Chemistry of the terpenes, p. 109.) Dextro-rotatory phellandrene has, however, been found to occur in the oils of some plants with a much higher rotation than that shown by Pesci.

Lævo-phellandrene from Eucalyptus oil has previously been shown to have a particularly high rotation, and Schimmel and Co. have recorded the following constants for a sample they prepared:—Boiling point 173–175° C. (754 mm.); 50–52° (5 mm.); specific gravity at 15° C. = 0.848; optical rotation  $a_D - 84.10^\circ$ ; refractive index at 20° = 1.47694.

We have prepared a sample of phellandrene from the oil of *E. dives*, in as pure a condition as possible, which had a considerably higher rotation than that recorded by Schimmel and Co. Our sample gave the following constants:—Boiling point 61° (11 mm.); specific gravity at 15° C. = 0.845; optical rotation  $a_D - 102.1^\circ$ ; refractive index at 20° = 1.4740. The nitrosite, as first prepared, melted at 110–111° C. and had specific rotation, in chloroform solution,  $[a]_D + 134.8^\circ$ .

This sample possessed the highest rotation to the left of any of those we have so far prepared.

In 1903, Semmler [Ber. 36 (1903), 1749] showed that crude phellandrene from Eucalyptus oil contained two isomeric phellandrenes, together with small quantities of cymene and cineol. The phellandrenes on oxidation with potassium permanganate gave distinct acids, and from the study of these oxidation products he considered the acids to have been derived from two different isomeric



phellandrenes; to these he gave the names normal-phellandrene and pseudo-phellandrene. In recent determinations these isomers are usually referred to as the  $\alpha$ - and  $\beta$ -forms of phellandrene.

Wallach and Beschke [Ann. 336 (1904) 9] undertook an extensive investigation with the phellandrenes, and the conclusion to which they arrive is that lævo-phellandrene from Eucalyptus oil is *l*- $\alpha$ -phellandrene.

It appears, however, that both the *l*- $\alpha$ -phellandrene and the *l*- $\beta$ -phellandrene do occur in Eucalyptus oils, but where the line of demarcation exists in the genus is not at present clear. It is probable that the  $\beta$ -form is present in greatest abundance in the oils of those species in which the cyclic aromatic aldehydes occur, as for instance those of certain "Boxes," because cymene is always a pronounced constituent in the oils of this group, whereas in those of the "peppermint" group of Eucalypts, the principal phellandrene is the  $\alpha$ -form, and associated with piperitone. It would thus be interesting to know from which Eucalypt the oil upon which Semmler worked was derived.

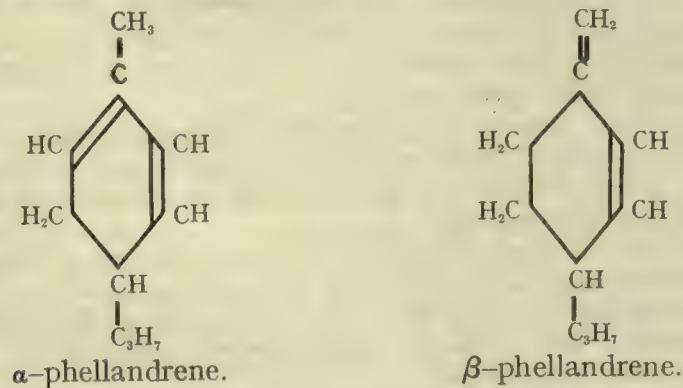
Both the  $\alpha$ - and  $\beta$ -forms of phellandrene have been synthesised, the normal or  $\alpha$ -form by Harries and Johnson [Ber. 38 (1905) 1832], and the pseudo or  $\beta$ -form by Kondakow and Schindelmeister [J. pr. Ch. II, 72 (1905) 193].

The normal or  $\alpha$ -form was prepared from the ketone carvone. The required menthenone was first made, and this when treated with phosphorus pentachloride formed the required chlorophellandrene, which on reduction with zinc dust in methyl alcohol was converted into  $\alpha$ -phellandrene.

The pseudo or  $\beta$ -form was also obtained through carvone, the tertiary carvomenthene being first prepared. This hydrocarbon reacted with bromine to form the dibromide, and this substance, when treated with alcoholic potash, formed the  $\beta$ -phellandrene.

The normal or  $\alpha$ -phellandrene was also synthesised from Sabina ketone by Wallach and Heyer [Ann. 359 (1908) 2652-2686].

The two forms of phellandrene are considered to have the following structures:—



Phellandrene readily yields a nitrosite  $C_{10}H_{16}N_2O_3$ , and this reaction is employed for the detection of this terpene in Eucalyptus oils; it may be carried out in the following manner:—5 c.c. of the oil to be tested are dissolved in 10 c.c. of petroleum ether, and to the mixture is added half the volume of a saturated aqueous solution of sodium nitrite; 5 c.c. of glacial acetic acid are then added in order to liberate the nitrous acid. The amount of resulting crystalline compound will serve to indicate whether much or little phellandrene is present in the oil, this result being confirmed by the physical properties of the particular sample. If desired the crystals may be recovered by filtration, washed with water and alcohol, and then dissolved in chloroform and again precipitated by the addition of alcohol.

The nitrosite from the lævo-rotatory phellandrene is strongly dextro-rotatory, while that from dextro-phellandrene is lævo-rotatory, but both are similar in appearance and melt at the same temperature. They have been shown by Wallach and Beschke (*loc. cit.*) to form two isomeric nitrosites, which may be separated by crystallising from acetone and alcohol; the lævo- $\alpha$ -phellandrene- $\alpha$ -nitrosite melting at 112–113° C., and the lævo- $\alpha$ -phellandrene- $\beta$ -nitrosite at 105° C.; the dextro forms melted also at the same temperature.

## Terpinene in Eucalyptus Oils.

THE occurrence of this terpene in the oils of certain Eucalypts was first announced by one of us, in a paper read before the Royal Society of New South Wales in December, 1918. It had been isolated from the oil of *E. megacarpa*, a West Australian species, forwarded to the Technological Museum for investigation by Mr. C. E. Lane-Poole, the Conservator of Forests for that State.

The oil of this Eucalypt consists principally of terpenes, and in addition to the terpinene, pinene and limonene were both detected, and their characteristic chemical combinations prepared.

Limonene rarely occurs in Eucalyptus oils, and it may be that terpinene will be found more frequently associated with that terpene in the oils of species growing in the northern and north-western portion of Australia, and at present uninvestigated. The formation of terpinene from terpineol through the terpene terpinolene is thus of special interest, because dipentene can also be formed from terpineol, and it is now known that this alcohol is a common constituent in the oils of many Eucalyptus species.

The pinene and limonene in the oil of *E. megacarpa* were both lævo-rotatory, and it is possible that dipentene was present also. The cineol content was 30 per cent., and from the aggregate of results it appears that about 10 per cent. of terpinene was present also.

Terpinene can be formed artificially by the action of alcoholic sulphuric acid on many of the terpenes and terpene derivatives, as well as from terpineol, geraniol, dihydrocarveol, and cineol. This formation is thus interesting in this connection, as besides cineol, pinene, and limonene, geraniol was also present as an ester in the oil of *E. megacarpa*.

Terpinene was first recognised as a separate terpene by Wallach [Ann. (230) 254], but has so far been detected in only a very few essential oils, such as those of Marjoram, Dill, and Coriander. It has been suggested that in these cases its presence may have been brought about by the influence of heat during distillation, but this opinion cannot now be supported in so far as it relates to Eucalyptus oils.

Terpinene has not, so far, been regenerated from its solid derivative in a pure form, so that its physical properties cannot be definitely stated, but from the results of various observations the following may be given:—Boiling point, 171–181° C.; specific gravity, 0.842 at 22° C. to 0.848° at 18°; refractive index, 1.4719 to 1.4789.

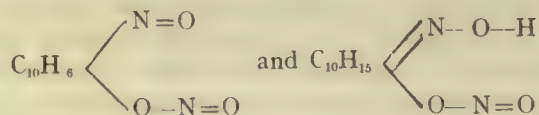


The two reactions which serve to distinguish terpinene from other terpenes are: (a) the crystallised nitrosite,  $C_{10}H_{16}N_2O_3$ , melting at  $155^\circ$  C., which is formed when the oil is treated with nitrous acid; and (b) the comparative ease with which it is destroyed when treated in the cold with Beckmann's chromic acid mixture; this reagent under such conditions has little action upon either pinene, limonene, or cineol.

(a) THE FORMATION OF THE TERPINENE NITROSITE.

A portion of the oil of *E. megacarpa* boiling between  $170$ – $190^\circ$  C. was mixed with an equal quantity of petroleum ether and an equal bulk of a saturated solution of sodium nitrite added, and afterwards sufficient glacial acetic acid to decompose the salt. The whole was then allowed to stand on one side. After twenty-four to thirty hours, crystals commenced to form, and increased considerably in amount after two days. The crystals were separated, pressed on porous plate to absorb the liquid products, and purified from a mixture of alcohol and chloroform. The terpinene nitrosite thus formed melted at  $155^\circ$  C. (corr.), and answered to the more easily applied chemical reactions for this substance.

Terpinene nitrosite, which is a much more stable substance than the corresponding compound formed with phellandrene, has had the two following formulæ suggested for it, but no decision as to which is correct has yet been arrived at.



(b) TREATMENT WITH BECKMANN'S REAGENT.

A portion of the fraction boiling between  $170$ – $190^\circ$  was repeatedly treated in the cold with small quantities of Beckmann's chromic acid mixture, until the formation of the brown precipitate was less noticeable. The optical rotation of the fraction before treatment was  $35.6^\circ$  to the left, due principally to the lævo-rotatory limonene. After the first treatment, the optical rotation had increased to  $36.4^\circ$ , and after further action to  $36.6^\circ$ . The substance removed was evidently the inactive terpinene, the treatment apparently having little action on the activity of the limonene.

*E. megacarpa*, in the sequence of species, approaches more nearly the earlier members of the genus, and this is also indicated by the principal chemical constituent in the oil being pinene. The chief terpene in the oils of the more recent species of the genus is phellandrene, so that a peculiarity is noticed here, in that terpinene is found at that end of the genus more largely represented in Western Australia, while the other closely agreeing terpene (phellandrene) is a characteristic constituent in the oils of certain Eucalypts which occur more abundantly in the eastern and south-eastern portion of the Continent. (See also the map in this connection, Plate II.)



## Aromadendrene—the Sesquiterpene of Eucalyptus Oils.

A SESQUITERTENE occurs in most crude Eucalyptus oils, perhaps in all of them, although it is present in but small amount in many of those belonging to the "Peppermint" group. It does not appear to be associated with one terpene more than another, because it has been found in quantity in some of the pinene oils (those occupying the earlier portion of the series), in which phellandrene is absent; and also in oils in which pinene is only present in small quantity, with phellandrene the principal terpene. It is also found in the oils belonging to the cineol-pinene group.

The sesquiterpene was first detected in quantity in the oil of *E. Dawsoni*, where it occurs with phellandrene; it was also present in quantity in those of the following species:—*E. eximia* (with pinene); *E. nova-anglica* (with pinene); *E. trachyphloia* (with pinene); *E. affinis* (with pinene and cineol); *E. maculata* (with pinene and cineol); *E. acmenioides* (with pinene and phellandrene); *E. crebra* (with pinene, phellandrene, and cineol); *E. viminalis* (with pinene, phellandrene, and cineol); *E. hæmastoma* (with phellandrene), and as a well-defined constituent in the oils of many other species. The oil of *E. nova-anglica* contains the sesquiterpene in great quantity, and over 50 per cent. of the crude oil distilled above 255° C. It appears to be a constant constituent in those oils in which it is found, and in that of *E. hæmastoma* distilled from material sent from Gosford, N.S.W., and from Barber's Creek, N.S.W., localities about 140 miles apart, practically the same amount of the sesquiterpene was present. The oil from the Gosford sample gave 50 per cent. boiling between 255° and 280° C., and that from Barber's Creek, 55 per cent. distilling between 245° and 283° C. The oil of *E. hæmastoma* was the one employed originally for the separation of the sesquiterpene. In all the above oils the sesquiterpene was accompanied by a sesquiterpene alcohol in larger or smaller amount.

There appears to be only the one sesquiterpene in Eucalyptus oils, because the high-boiling portions of those of several species were added together, and the product obtained from this, by fractional distillation, finally over sodium, was practically identical with that obtained from the oil of *E. hæmastoma* in a similar manner.

Although the sesquiterpene has been prepared as free as possible from associated constituents by fractional distillation, finally over sodium, yet it cannot, as thus obtained, be considered pure. All efforts, so far, to form crystallised chemical compounds with it have not been successful; the constants cannot, therefore, be given with any very great degree of accuracy. Attempts were made to form the crystalline dihydrochloride, the nitrosochloride, and the nitrosite, but these were not satisfactory; nor did it appear possible to obtain a solid sesquiterpene alcohol from it by treatment with glacial acetic acid and sulphuric acid, so that its derivatives have yet to be prepared.

When treated with bromine, very energetic action takes place with the evolution of hydrobromic acid; the bromide is of a very dark colour, and not obtained in a crystallised condition.

A characteristic test for this sesquiterpene is the very fine colour reactions it gives with bromine, and with the halogen acids.

The bromine test is best carried out in the following manner :—

One or two drops of the sesquiterpene are dissolved in 2 or 3 c.c. of glacial acetic acid, and the vapour of bromine allowed to pass down the tube until it reaches the liquid; a crimson colour is immediately formed, which rapidly passes downward and throughout the whole of the liquid; if agitated the whole becomes crimson, soon changing to violet, and in a short time to a deep indigo-blue colour, which, under favourable conditions, remains for some days. This test is exceedingly delicate, but the bromine should not be added in excess. The reaction appears to be due to the formation of hydrobromic acid immediately the bromine meets the sesquiterpene, and identical colour reactions were obtained when one or two drops of hydrobromic acid were added directly to the acetic acid solution, not mixing the two liquids. On heating the blue liquids, they became reddish-brown, but usually recovered the indigo-blue colour on standing.

When one or two drops of concentrated hydrochloric acid were added to the acetic acid solution, prepared as for the previous tests, a crimson colour was obtained at once; this soon changed to violet, and, on standing some hours, to an indigo-blue colour. Here again the colours were more brilliant if the liquids were not mixed by agitation.

When one or two drops of concentrated sulphuric acid were passed to the bottom of an acetic acid solution prepared as above, a bright crimson colour was at once formed at the junction of the liquids; on mixing these, the crimson colour first formed, changed to a purplish-brown rather than to the violet colour formed with the halogen acids. On boiling, the solution first became violet, then deep crimson.

When a few drops of phosphoric acid (specific gravity 1.75) were added to the acetic acid solution prepared as above, a rose-madder colour formed at the junction of the liquids; on mixing the acids after the colour had formed, the liquid changed in a few minutes to crimson, and then slowly to violet. It is thus evident that the pink colour given to Eucalyptus oils when treated with phosphoric acid is due to the influence of the sesquiterpene.

In order to prepare the sesquiterpene in as pure a condition as possible, 300 c.c. of the crude oil of *E. nova-anglica* were directly distilled under reduced pressure, and the fractionation repeated until finally 50 c.c. were obtained boiling at 124–125° C., at 10 millimetres pressure.

It was not easy to entirely separate the lævo-rotatory sesquiterpene alcohol from the dextro-rotatory sesquiterpene, and it was necessary to finally distil over sodium before an oil with a constant rotation was obtained. The sesquiterpene, when thus prepared, had a slight yellowish tinge, was quite mobile, had a not unpleasant odour, nor was it readily soluble in alcohol.

The constants for the sesquiterpene were determined as follows :—Boiling point, under ordinary atmospheric pressure 260–265° C., and under 10 millimetres pressure 124–125° C.; specific gravity at 15° C. = 0.9222; rotation  $\alpha_D$  + 4.7°; and refractive index at 20° = 1.4964.

Molecular refraction calculated for  $C_{15}H_{24}$  with one double bond = 64.45; found 64.89. It thus appears that aromadendrene contains one double linkage in the molecule.

An analysis gave the following results :—

0.1366 gram. gave 0.4388 gram.  $CO_2$  and 0.1502  $H_2O$ .

Carbon 87.6 per cent. and hydrogen, 12.2 per cent.

$C_{15}H_{24}$  requires 88.3 per cent. C., and 11.77 per cent. H.



In a paper read by one of us before the Roy. Soc. N.S.W., Nov., 1901, the name *Aromadendrene* was suggested for this sesquiterpene.

A sample of the sesquiterpene was similarly prepared from the oil of *E. Baileyana*. The constants were in agreement with those recorded above, with the exception that the sesquiterpene was lævo-rotatory. It boiled at 123–125° C. at 10 millimetres; had specific gravity at 15° C. = 0.9240; optical rotation  $\alpha_D$  = 3.7°; and refractive index at 20° = 1.4964.

The characteristic colour reactions will detect the presence of this sesquiterpene in many crude Eucalyptus oils. It can also be shown by this method to occur in that of *Angophora lanceolata*.

## The Paraffin Stearoptenes of Eucalyptus Oils.

THE first member of the paraffins (probably belonging to the aliphatic series) occurring in the Eucalypts was isolated from the crude oil of *E. acervula*, Hook.f., the "Red Gum" of Tasmania. This substance was first described in a paper published by us in the Proc. Roy. Soc., Tasmania, October, 1912. This paraffin is a saturated hydrocarbon, and probably belongs to the  $C_nH_{2n} + 2$  group. It resembles in appearance, odour on ignition, chemical behaviour, and general characters, the paraffin derived from mineral oils, generally known as "paraffin wax."

When finally purified, the stearoptene was perfectly white, of a paraffin-like nature, and without odour; on burning, the odour was identical with that of ordinary paraffin when similarly heated and ignited. The melting point was 55 to 56° C., determined by the capillary tube method in water, and in other ways.

Under the microscope it was seen to be crystalline, and when melted and allowed to slowly cool, the crystals polarised in colours. They were not very symmetrical however, but vermiform, often tending to the shape of the letter S. When dissolved in carbon tetrachloride, and bromide added, the colour was not removed; it was thus a saturated substance. Concentrated sulphuric acid had no action upon it in the cold, nor did the usual oxidising mixture of potassium bichromate and sulphuric acid act upon it in the cold, and only slightly on continued boiling. Concentrated nitric acid appeared to have no action in the cold, and it was but slowly attacked on boiling, acting in this respect similarly to the ordinary paraffins. A solution of potassium permanganate in the cold had no action on it after many days.

Although the paraffin was isolated from the oil of *E. acervula*, from material collected from two different localities in Tasmania, yet the melting point for both samples was identical. The melting point, 55 to 56° C., cannot, however, be taken as that of Eucalyptus paraffins generally, and the corresponding stearoptene isolated from the oil of *E. Smithii*, melted at 64° C. (See paper Roy. Soc., N.S.W., July, 1913.)

It is thought that these paraffins probably consist of two or more homologues, and this is suggested from the results obtained with the oil of *E. acervula*, which apparently contained a second paraffin, liquid at ordinary temperatures. The higher melting point of the stearoptene from *E. Smithii*, over that from *E. acervula*, is perhaps one distinguishing feature between the oils of the different groups.



The aliphatic paraffins cannot be considered as very rare constituents in essential oils, as their presence has been shown in those of more than a dozen different plants. Essential oils containing paraffin in greatest amount are Rose oil and Chamomile oil, and in these the stearoptene is often so abundant that the oil congeals on cooling. The paraffin recorded from Neroli oil melts at exactly the same temperature as that from the oil of *E. acervula*, while that in Chamomile oil only differs by one degree. No less than eight paraffins have been recorded from other essential oils, the melting points of which are within one degree of that isolated from the oil of *E. Smithii*.

It is perhaps worthy of remark that the first paraffin isolated from the Eucalypts was from the oil of a species (*E. acervula*) which contains a considerable amount of geraniol, a constituent also present in Rose oil. On the other hand the oil of *E. Macarthuri*, which has a very large amount of geraniol, does not appear to contain it. That the paraffin was derived from the leaf oils of *E. acervula* and *E. Smithii* is evident from the fact that these species were not in bloom when the oil was distilled.

**Methods of Preparation.**—Portions of the crude oils of two consignments of *E. acervula* were dissolved in a large excess of 80 per cent. alcohol, when a copious, flocculent substance separated. The precipitate was filtered off, using a hardened filter, washed with alcohol, and the solid fat-like substance melted on the water bath to separate adhering water and alcohol. The amount of crude material thus obtained from the oil of one sample was equal to 0.76 per cent., and from the other 0.82 per cent. This method, however, was somewhat wasteful. The crude oil was then distilled, when the portion boiling above 280° C. became semi-solid when cold; this was boiled in alcohol, filtered hot, cooled, and the process repeated. After standing some time the precipitate was filtered off and boiled in acetic ether, which was found to be a good solvent for the purpose, as the paraffin was little soluble in the cold. On cooling, the substance separated, most of the impurities remaining in solution. The semi-crystalline paraffin was then boiled in alcohol, a little animal charcoal added, and filtered hot. It was finally dissolved in chloroform and precipitated by the addition of alcohol. When thus obtained it differed in no respect from the corresponding material precipitated directly from the crude oil by alcohol.

The paraffin was separated from the oil of *E. Smithii* by steam distilling the oil until the greater portion had come over, and treating the residue with cold 80 per cent. alcohol, when the paraffin was precipitated. It was then purified in a similar manner to that of *E. acervula*.

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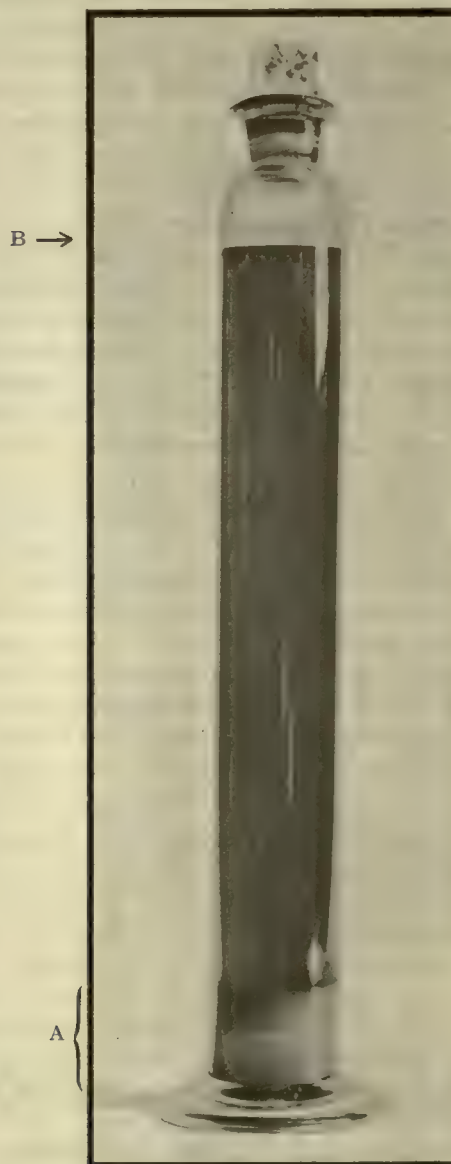
## The Deposit which forms in the Oils of some Species of Eucalyptus.

THE oils of certain Eucalypts, when freshly distilled, contain a constituent which slowly changes its character and eventually deposits an insoluble precipitate. This constituent is never present in great quantity, and in some instances only in traces. In the majority of species it is absent, and appears to follow the general rule of all Eucalyptus oil constituents, in increasing in amount through a range of species until a maximum is reached in one or more of them.

Very many Eucalyptus oils, from authentic species, have now been under observation for several years in the Museum, and we have thus been able to determine in which of them this deposit has formed.

Reference was made to it in the first edition of this work, but the evidence then available was insufficient to enable general conclusions to be drawn. It may now be stated that none of the oils of species belonging to the groups yielding the more pronounced pinene oils, in which cineol is only present in small amount, has any signs of the deposit appeared, nor in that of any member belonging to

PLATE LXXXVIII.



CRUDE OIL OF EUCALYPTUS GONIOCALYX.

Illustrating the deposit (A) and (B) the diminution in volume.

the typical "Boxes," *E. hemiphloia*, &c., and closely agreeing Eucalypts. In no species, the oil of which contains phellandrene, has it been detected, but is most in evidence in oils distilled from Eucalypts belonging to the typical "Gum" group :—*E. globulus*, *E. goniocalyx*, &c., and closely-related species.



The oils of these Eucalypts usually contain a fairly large amount of cineol, together with pinene, and in the case of many members belonging to these groups, the cineol increases in amount when the oils are stored. By reason of this peculiarity it was thought that the formation of this deposit was connected, in some way, with this increase in cineol, but the evidence available hardly supports that supposition, particularly as the oils of *E. goniocalyx*, *E. punctata*, and *E. maculosa* have not increased their cineol content during twenty years, although the deposit was quite pronounced in all three. It may also be mentioned that the cineol has increased in the oil of *E. eugenioides*, and one or two others, in which no precipitate has formed.

Although the deposit is so insoluble in all organic solvents, except chloroform, yet it has been found in solution in the oil itself in two or three instances, and precipitated when these were fractionated. One sample was distilled in Western Australia from a species growing in that State, and forwarded to us by Mr. C. E. Lane Poole; another sample was from Queensland, and sent to us by the late Mr. P. McMahon. In neither case was botanical material available, so that the species remain undetermined.

Plate LXXXVIII will serve to show the appearance of the deposit after the precipitation was complete, and the amount so derived from the quantity of oil in the bottle. When originally placed in the show-case the oil was quite clear.

The following list records the species in the oils of which this deposit has formed. The percentages of cineol in the crude oils, when first distilled, are given, also percentages in some of the same samples about twenty years afterwards; in both cases the determinations were made by the phosphoric acid method:—

|                                | Cineol when<br>first<br>distilled. | Cineol after<br>about 20<br>years. |                                | Cineol when<br>first<br>distilled. | Cineol<br>after<br>about 20<br>years. |
|--------------------------------|------------------------------------|------------------------------------|--------------------------------|------------------------------------|---------------------------------------|
| <i>Eucalyptus accedens</i> ... | 43                                 | ...                                | <i>Eucalyptus Morrisii</i> ... | 60                                 | 64                                    |
| <i>E. bicolor</i> ...          | 48                                 | 62                                 | <i>E. Muellieri</i> ...        | 57                                 | ...                                   |
| <i>E. cordata</i> ...          | 55                                 | 65                                 | <i>E. occidentalis</i> ...     | 36                                 | ...                                   |
| <i>E. cosmophylla</i> ...      | 43                                 | ...                                | <i>E. odorata</i> ...          | 63                                 | ...                                   |
| <i>E. costata</i> ...          | 57                                 | ...                                | <i>E. oleosa</i> ...           | 52                                 | 62                                    |
| <i>E. dealbata</i> ...         | 52                                 | 73                                 | <i>E. platypus</i> ...         | 48                                 | ...                                   |
| <i>E. dumosa</i> ...           | 44                                 | ...                                | <i>E. populifolia</i> ...      | 62                                 | 70                                    |
| <i>E. elaeophora</i> ...       | 58                                 | 66                                 | <i>E. propinqua</i> ...        | 32                                 | 39                                    |
| <i>E. globulus</i> ...         | 57                                 | 64                                 | <i>E. punctata</i> ...         | 55                                 | 55                                    |
| <i>E. goniocalyx</i> ...       | 56                                 | 56                                 | <i>E. quadrangulata</i> ...    | 32                                 | 54                                    |
| <i>E. gracilis</i> ...         | 19                                 | 30                                 | <i>E. redunca</i> ...          | 38                                 | ...                                   |
| <i>E. hemilampra</i> ...       | 35                                 | 50                                 | <i>E. Rodwayi</i> ...          | 50                                 | ...                                   |
| <i>E. intertexta</i> ...       | 35                                 | 60                                 | <i>E. Seeana</i> ...           | 52                                 | 58                                    |
| <i>E. Lehmanni</i> ...         | 20                                 | ...                                | <i>E. squamosa</i> ...         | 56                                 | 70                                    |
| <i>E. leucoxydon</i> ...       | 27                                 | ...                                | <i>E. urnigera</i> ...         | 53                                 | ...                                   |
| <i>E. maculosa</i> ...         | 55                                 | 55                                 | <i>E. vernicosa</i> ...        | 52                                 | ...                                   |
| <i>E. microcorys</i> ...       | 10                                 | 30                                 |                                |                                    |                                       |

In the diagram illustrating the article dealing with the probable evolution of the Eucalypts, all the above species will be found towards the left, and if a line be drawn from *E. maculata* to *E. tereticornis*, and another from *E. tereticornis* to *E. apiculata*, not one of the species in the above list will be found to the right



of those lines. It is thus seen that only about one-fifth of the oils so far investigated appear to contain the constituent which on alteration forms this deposit, and these were all distilled from species belonging to closely related groups, the principal oil constituents of which are cineol and pinene.

That the deposit consists of a polymerised body is shown from its general character and exceedingly high molecular weight; it also shows a fairly constant composition with most species in which it occurs, as is evident from the results of the analyses, and the closely agreeing molecular weight determinations.

Its composition and chemical behaviour, as well as its alteration when heated, apparently show it to be associated with the neutral resins. After three or four years the polymerisation appeared to be complete, as no further formation of the deposit took place in the filtered oils after that period.

#### EXPERIMENTAL.

The substance was purified by filtering off the deposit which was thus obtained as a jelly-like mass; it was spread upon porous plates to absorb the adhering oil, finely ground, dissolved in chloroform and precipitated by the addition of an excess of alcohol. The process was repeated several times, when in most cases the finely-ground powder was quite white and had little cohesion.

When purified as above all the samples contained minute traces of manganese or alumina, and occasionally iron, but neither lime nor magnesia was detected. In those cases where a reaction for iron was obtained the powder was slightly tinted, and it did not appear possible to remove this by repeated solution and reprecipitation.

The powder was quite neutral, was insoluble in alkalis and in all the usual organic solvents except dry chloroform. It was soluble in sulphuric acid with the formation of an orange-brown solution, but on addition of water was again precipitated apparently unchanged.

The melting point was very high, in most cases about 280–290° C., although that of *E. punctata* melted fairly well at 265–270° C. The melted substance was a brown brittle resin, mostly soluble in alcohol and in hot aqueous alkalis; the portion soluble in alcohol melted at 125–130° C. When heated in the tube to slight decomposition it evolved an odour reminding one of an aromatic resin, and gave off a small quantity of a volatile liquid which was acid to litmus.

The empirical formula obtained with the deposits of *E. oleosa*, *E. populi-folia*, and the undetermined species from Queensland, was  $C_7H_{10}O$  in each case, but with those of *E. punctata* and *E. occidentalis* it was  $C_8H_{12}O$ . Molecular weight determinations were carried out by the Landsberger boiling point method, using chloroform as solvent. The results were fairly uniform for material of this character, although the molecular weight was so high.

With the deposit from *E. globulus* the following was obtained:—1.0416 gram. gave the figure 1.368 for *ev* as the mean of several readings, so that the molecular weight was 1979.

With that from *E. occidentalis* 1.1256 gram. gave the figure 1.492, molecular weight = 1960. With that from the undetermined species from Queensland:—1.685 gram. gave the figure 2.2, molecular weight = 1992. Calculating from the empirical result with the deposit from the Queensland species, the molecular formula is  $C_{126}H_{180}O_{18}$ , and with that from *E. occidentalis*  $C_{128}H_{192}O_{16}$ .

The specific gravity of the powder was 1.08. It also gave a saponification number 87, and an iodine value 105, although no absorption of bromine was shown in the chloroform solution.

## The Comparative Constancy of the Oil Products from Individual Species of Eucalyptus.

THIS question may be considered as one of considerable importance to the distiller, particularly as Eucalyptus trees are so abundant in Australia, the greater portion of the natural vegetation of the country being composed of trees belonging to this genus.

The leaves of all the Eucalypts are evergreen, so that distillation can proceed throughout the year, but the oil is less in amount during the winter months. Although practically all the species contain an essential oil, yet, with many of them, the yield is very small indeed, and thus they are not profitable to work. (See table of yields in separate list.)

From a commercial point of view only a small percentage of the species can be utilised for oil production, the principal reasons for such limitation being (1) the constitution of the oil itself, and (2) the variation in the amounts of oil yielded by the several species.

The competition for trade among the distillers naturally causes those species which produce the greatest amount of oil per tank,\* all else being equal, to be the most in demand, and consequently distillation from material growing naturally can only be carried on profitably in those portions of the country where the desired species abound. It has been this question of yield that, among the richer cineol-bearing oils, has caused *E. globulus* to recede in the world's markets from the position it once held, and in Australia to-day only a very small amount of oil is distilled from that species, the reason being that the yield is too small in amount for it to compete satisfactorily with the more profitable Eucalypts, such as *E. polybractea*, *E. Australiana*, *E. cneorifolia*, *E. Smithii*, &c., all of which furnish rich cineol oils, and give practically double the amount from the same weight of leaf material as from *E. globulus*. In the case of *E. Australiana* the yield is three times as great.

In view of the geographical distribution of the genus in Australia, with an area of 3,000,000 square miles, the number of distinct species is comparatively not great, but their oil products vary much in constitution among themselves, although comparatively constant for individual species.

The large amount of research which has been carried out during recent years on their oils, has demonstrated quite clearly that a particular Eucalyptus species will produce—from average material—an oil practically constant in composition and general characters,† and also give a fairly uniform yield, providing the material for distillation has been well selected and not too coarsely cut, or with too many branchlets.

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\* In some parts of Australia, New South Wales particularly, the standard upon which payment is made for cutting the leaf material, for calculating the contents of the digesters, and the statement of oil produced, is the 400-gallon square-iron tank, which holds approximately 800 pounds of material when filled for open firing.

† This matter is more fully considered in the early article dealing with the comparative constancy of specific characters of Eucalyptus species.



It has been this comparative constancy in the oils of identical species that has enabled the somewhat extensive trade in Eucalyptus oils—from naturally growing trees—to have been built up. Had it been otherwise there could hardly have been the desired constancy in the commercial article, nor could necessary standards for control have been arranged.

In order to illustrate this constancy in general characters from *commercially collected material*, the three tables below are given. The three species chosen are to be considered as types of groups, and all are now extensively utilised for oil production in New South Wales and Victoria.

The oils to which the figures refer were in these cases distilled for market, and forwarded to the Museum for investigation. There is not the slightest doubt, however, with the specimens tabulated, as to the botanical identity of the species from which the oils had been distilled. It will be noticed that the dates of the distillations extend over several years.

Space will only permit the tabulation of a few of the results, but they are sufficient to show the small range of variation in the chemical constituents likely to be observed in commercially distilled Eucalyptus oils when from one species only. Similar data from other species might equally well have been given, if thought necessary, as, for instance, with the perfumery oils *E. Macarthurii*, *E. citriodora*, &c., but a perusal of the results recorded in this work, under the several species, will supply abundant evidence of this comparative constancy of their oil products.

The figures quoted are those published by one of us in the Journal of the Society of Chemical Industry, August, 1918, in a paper prepared to illustrate the value of the Refractometer for determinative purposes, but they may be equally well applied in the present connection.

(1) *EUCALYPTUS POLYBRACTEA* (a species distilled in both New South Wales and Victoria).

| Place and date.                                | Specific gravity at<br>15° C. | Optical rotation<br><i>α</i> <sub>D</sub> . | Refractive index<br>at 20° C. |
|------------------------------------------------|-------------------------------|---------------------------------------------|-------------------------------|
| Crude oil.—Wyalong, N.S.W., July, 1907 ...     | 0.9245                        | + 0.8°                                      | 1.4631                        |
| Crude oil.—Wyalong, N.S.W., July, 1909 ...     | 0.9269                        | + 0.6°                                      | 1.4633                        |
| Rectified oil.—Wyalong, N.S.W., Dec., 1911 ... | 0.9264                        | + 0.5°                                      | 1.4586                        |
| Rectified oil.—Wyalong, N.S.W., Oct., 1912 ... | 0.9271                        | + 0.4°                                      | 1.4596                        |
| Rectified oil.—Wyalong, N.S.W., Nov., 1912...  | 0.9256                        | + 0.5°                                      | 1.4598                        |
| Rectified oil.—Bendigo, Vic., Jan., 1913 ...   | 0.9273                        | — 0.2°                                      | 1.4602                        |
| Rectified oil.—Wyalong, N.S.W., Oct., 1913 ... | 0.9270                        | + 0.4°                                      | 1.4612                        |
| Crude oil.—Wyalong, N.S.W., Mar., 1914 ...     | 0.9292                        | — 0.3°                                      | 1.4624                        |
| Rectified oil.—Wyalong, N.S.W., May, 1914 ...  | 0.9270                        | + 0.3°                                      | 1.4598                        |
| Rectified oil.—Wyalong, N.S.W., Sept., 1914... | 0.9298                        | + 0.2°                                      | 1.4608                        |
| Rectified oil.—Wyalong, N.S.W., July, 1916...  | 0.9300                        | + 0.5°                                      | 1.4596                        |
| Rectified oil.—Wyalong, N.S.W., Feb., 1917...  | 0.9195                        | + 0.3°                                      | 1.4598                        |

It will be seen that only two oils listed were lævo-rotatory. This is due to the influence of a small quantity of the optically active aromatic aldehyde aromadendral, and indicates that the distillation of the leaves had been extended



beyond the usual time. This lævo-rotation is not due to the presence of phellandrene, as that terpene does not occur in any of the oils of this group.

The oil of *E. polybractea* is one of the richest in cineol, and in the particular cases listed above, that constituent was always in the neighbourhood of 80 per cent.

The solubility was always high; only from 1.1 to 1.2 volumes 70 per cent. alcohol being required to form a clear solution.

(2) *EUCALYPTUS AUSTRALIANA*, "First hour oil." .

"NARROW LEAF" OR "BLACK PEPPERMINT."

(A species distilled in New South Wales.)

| Place and date.                                   | Specific gravity at<br>15° C. | Optical rotation<br>$\alpha_D$ . | Refractive index<br>at 20° C. |
|---------------------------------------------------|-------------------------------|----------------------------------|-------------------------------|
| Nerrigundah, N.S.W., April, 1913 ... ..           | 0.9188                        | + 0.3°                           | 1.4621                        |
| Nerrigundah, N.S.W., Aug., 1913 ... ..            | 0.9193                        | + 0.9°                           | 1.4628                        |
| Yourie, N.S.W., Aug., 1913 ... ..                 | 0.9186                        | + 0.5°                           | 1.4624                        |
| Yourie, N.S.W., another distiller, Sept., 1913... | 0.9195                        | + 0.4°                           | 1.4622                        |
| Nerrigundah, N.S.W., April, 1914 ... ..           | 0.9193                        | + 1.5°                           | 1.4631                        |
| Yourie, N.S.W., April, 1914 ... ..                | 0.9199                        | + 0.1°                           | 1.4622                        |
| Yourie, N.S.W., Aug., 1914 ... ..                 | 0.9202                        | 1.2°                             | 1.4636                        |
| Nerrigundah, N.S.W., Mar., 1914 ... ..            | 0.9195                        | + 1.4°                           | 1.4631                        |
| Reedy Creek, Nerrigundah, N.S.W., Sept., 1915     | 0.9196                        | + 1.2°                           | 1.4625                        |
| Yourie, N.S.W., Mar., 1916 ... ..                 | 0.9193                        | + 1.3°                           | 1.4626                        |
| Bellimbla, N.S.W., Mar., 1917 ... ..              | 0.9186                        | + 1.7°                           | 1.4617                        |
| Yourie, N.S.W., Mar., 1917 ... ..                 | 0.9205                        | + 1.6°                           | 1.4635                        |
| Wyndham, N.S.W., April, 1917 ... ..               | 0.9220                        | + 0.7°                           | 1.4635                        |

In the first edition of this work (page 170, under *E. amygdalina*) it was shown that by fractional separation during the primary distillation, the oil which came over during the first hour contained the greater portion of the cineol. It is only within the last six or seven years, however, that this mode of procedure has been adopted in commercial distillation, but during that time considerable quantities of a high-class water-white cineol oil have been distilled from *E. Australiana* in this way. The product so separated is known commercially as "First hour oil," and is sold for pharmaceutical purposes, the portion distilling later, which contains terpineol and geraniol, being employed in other branches of industry.

Although this "First hour oil" is thus collected empirically, yet it is remarkable how closely the results agree; the oil has a pleasant odour, contains about 70 per cent. of cineol, and will no doubt be in great demand when it becomes better known. Its solubility in alcohol is quite equal to that of the oil of *E. polybractea*.

(3) *EUCALYPTUS DIVES*.

## A "BROAD-LEAF PEPPERMINT."

(A species distilled in both New South Wales and Victoria.)

| Place and date.                                               | Specific gravity at<br>15° C. | Optical rotation<br><i>a<sub>D</sub></i> . | Refractive index<br>at 20° C. |
|---------------------------------------------------------------|-------------------------------|--------------------------------------------|-------------------------------|
| Cooma, N.S.W., Nov., 1913 ... ..                              | 0.8928                        | — 61.3°                                    | 1.4803                        |
| Colombo, N.S.W., May, 1914 ... ..                             | 0.8976                        | — 62.3°                                    | 1.4803                        |
| Mongarlowe, N.S.W., July, 1916, four hours'<br>distillation.  | 0.8892                        | — 69.8°                                    | 1.4798                        |
| Mongarlowe, N.S.W., July, 1916, eight hours'<br>distillation. | 0.9004                        | — 63.9°                                    | 1.4811                        |
| Colombo, N.S.W., Oct., 1916 (extended dis-<br>tillation).     | 0.9020                        | — 55.4°                                    | 1.4808                        |
| Mongarlowe, N.S.W., Oct., 1916 (extended<br>distillation)     | 0.9011                        | — 59.3°                                    | 1.4806                        |
| Braidwood, N.S.W., Nov., 1916 (extended<br>distillation).     | 0.9001                        | — 56.7°                                    | 1.4809                        |
| Orange, N.S.W., Dec., 1916 ... ..                             | 0.8950                        | — 61.2°                                    | 1.4805                        |

This oil may be considered as the type of the extreme phellandrene Eucalyptus oils, and although inclined to alter its physical characters by age to a greater extent than those of the cineol-pinene class, yet, when freshly distilled, a relative constancy is noticeable, similarly with the oils of the other species of Eucalyptus. The exceedingly high optical rotation is chiefly due to the phellandrene, although the piperitone it contains is also lævo-rotatory; scarcely more than 5 per cent. of cineol is present at any time.

Much of the oil of this species has been forwarded to Europe as the product of *E. amygdalina*. Although regrettable, yet this misnaming was, to a certain extent, excusable, because *E. dives* was classified for a long time as a variety of *E. amygdalina*, and varietal names soon appear to lose their identity.

The oil of *E. dives* is considered the best of all essential oils for mineral separation by a flotation process, and considerable quantities have been used in Australia for the separation of metallic sulphides. When it was decided to use Eucalyptus oil for this purpose at Broken Hill, the first contract was for the supply of the oil of this species.

The tendency is now among some distillers in New South Wales to treat the leaves of *E. dives* for several hours. This extended distillation naturally results in the oil having a higher specific gravity, a less rotation, and to contain a greater proportion of Piperitone than the product of, say, a three or four hours' distillation; this is shown in the table above, but for flotation work both are of equal value. For Piperitone production extended distillation gives better returns.

Results illustrating this constancy in chemical characters with other species have been tabulated, and will be found distributed throughout this work; but after all this is only what might be expected, considering the extent of the genus; and from our work on the Tasmanian species it was shown that a large proportion of those Eucalypts growing on the island were identical with trees of the same species on the mainland. It is evident, therefore, that both the botanical and chemical characters must have been stabilised long before Tasmania was separated from Australia, and it is not difficult to accept similar conclusions for practically the whole of the species in the genus.



## The Variation in the Character of Eucalyptus Oils Distilled from Trees of Differing Ages and Forms of Growth.

THE data given in the previous article dealing with the comparative constancy of the oil products, only treat with those distilled from general material, and not from individual trees or selected growths. In order, therefore, to determine the variation in amount of constituents in oils from such material that might be expected, the following work was undertaken.

With the exception of two samples of *E. Smithii* (*f* and *g*), which were distilled by Mr. D. E. Chalker, of Hill Top, New South Wales, from general material, all were prepared at the Technological Museum, the leaves having been specially collected for the investigation, and with the exception of (*e*) all were from naturally growing trees.

The results dealing with the oils of *E. Smithii* were published in the Proc. Roy. Soc., N.S.W., August, 1915.

The material worked on is represented by the following stages of growth:—

- (*a*) Leaves from lopped trees, seven months' growth; collected May, 1913.
- (*b*) Leaves from lopped trees, fifteen months' growth; collected May, 1913.
- (*c*) Leaves from seedlings, twelve months' growth; collected June, 1914.
- (*d*) Leaves from seedlings two and a half years old; collected July, 1914.
- (*e*) Leaves from tree cultivated at Marrickville, near Sydney; collected June, 1915. (Tree, 3½ years old).
- (*f*) Leaves from general material, partly young; collected January, 1915.
- (*g*) Leaves from general material collected three weeks later than (*f*).
- (*h*) Leaves from old trees; collected March, 1913.

The constants, &c., given by the *crude oils* from the above material were as follows:—

| Specific gravity at<br>15° C. | Optical rotation<br><i>α</i> <sub>D</sub> | Refractive index<br>at 20° C. | Solubility in 70<br>per cent. alcohol. | Saponification<br>number. | Cineol,<br>per cent. |
|-------------------------------|-------------------------------------------|-------------------------------|----------------------------------------|---------------------------|----------------------|
|                               |                                           |                               | Required.                              |                           |                      |
| ( <i>a</i> ) 0.9098           | ... + 7.6°                                | 1.4636                        | 1.6 vols.                              | 4.8                       | 67.4                 |
| ( <i>b</i> ) 0.9157           | ... + 6.5°                                | 1.4635                        | 1.2 „                                  | 5.6                       | 74.2                 |
| ( <i>c</i> ) 0.9116           | ... + 9.2°                                | 1.4654                        | 2.1 „                                  | 1.3                       | 61.5                 |
| ( <i>d</i> ) 0.9139           | ... + 7.6°                                | 1.4643                        | 1.4 „                                  | 4.1                       | 69.0                 |
| ( <i>e</i> ) 0.9198           | ... + 4.7°                                | 1.4690                        | 1.2 „                                  | 2.7                       | 75.0                 |
| ( <i>f</i> ) 0.9156           | ... + 5.3°                                | 1.4599                        | 1.1 „                                  | 3.3                       | 80.7                 |
| ( <i>g</i> ) 0.9154           | ... + 5.1°                                | 1.4597                        | 1.1 „                                  | 3.1                       | 79.0                 |
| ( <i>h</i> ) 0.9210           | ... + 4.2°                                | 1.4613                        | 1.1 „                                  | 1.3                       | 85.2                 |

The cineol was in all cases determined by the resorcinol method, in the redistilled portion of the freshly obtained oils boiling below 190° C. and calculated for the original oil.

It will be noticed from the above table that the oil from the younger seedlings contained more dextro-rotatory pinene and less cineol than did that from the saplings two to three years old, and that the maximum cineol content was reached in the oil from leaves collected from older trees. This is true also



for the leaves which are reproduced from lopped old trees, and the oil from the seven months' "suckers" contained more cineol and less pinene than did that from twelve months' old seedlings, while that from the fifteen months' old "suckers" followed the same rule in respect to the two and a half years' old seedlings. It will be seen that the constants followed this change in constituents somewhat regularly. To a small extent these were governed by the length of time to which the leaves had been distilled, as naturally the heavier constituents were brought over with more difficulty. The factors which are influenced to the greatest extent appear to be the specific gravity and refractive index, and this was shown with (e), where the idea was to obtain, by longer distillation, as much of the crystallised eudesmol as possible. With (f) and (g) derived from general material commercially distilled, the oils were quite in agreement with those we obtained when this species was first investigated many years ago, which results are recorded under *E. Smithii* in this work. Thus the relative constancy with the oil of individual species is again shown.

### OILS OF *EUCALYPTUS PUNCTATA*.

(Material collected at Canterbury and Belmore, localities a few miles from Sydney.)

In May and June, 1897, a somewhat similar investigation had been undertaken, in order to determine what variations were likely to occur in the character of the oils derived from trees of a species belonging to the "Gum" group of Eucalypts. The oils from the species of this group often contain the aldehyde aromadendral as a characteristic constituent, and it is present in that of this species.

1. Leaves and branchlets from a tree of fair size.
2. Leaves and branchlets from a large tree.
3. "Sucker" or abnormal leaves.
4. Leaves and branchlets from a large tree.
5. General material from old trees.
6. Leaves and branchlets from young trees 20 to 30 feet high.
7. General material from trees of medium size.
8. Leaves and branchlets from one tree of medium size.
9. Leaves and branchlets from a large tree, the material being divided into two parts and distilled separately.
10. Equal volumes of the above oils mixed together.

Crude oils from the above material (1377 lb.) gave the following results:—

|    | Colour of crude oil. | Yield per cent. | Specific gravity<br>at 15° C. | Rotation $\alpha_D$ . | Cineol, per cent.<br>(O.M.) |
|----|----------------------|-----------------|-------------------------------|-----------------------|-----------------------------|
| 1  | Very light ... ..    | 1.19            | 0.9207                        | + 2.02°               | 60                          |
| 2  | Rather dark ... ..   | 0.75            | 0.9157                        | + 1.99°               | 50                          |
| 3  | Light ... ..         | 0.63            | 0.9184                        | + 4.07°               | 54                          |
| 4  | Rather dark ... ..   | 0.88            | 0.9220                        | — 0.84°               | 51                          |
| 5  | " ... ..             | 0.75            | 0.9144                        | + 1.25°               | 49                          |
| 6  | Light ... ..         | 0.84            | 0.9179                        | + 0.49°               | 64                          |
| 7  | Rather dark ... ..   | 0.73            | 0.9181                        | + 0.49°               | 58                          |
| 8  | Light ... ..         | 0.66            | 0.9164                        | + 0.60°               | 56                          |
| 9  | Dark... ..           | 0.72            | 0.9129                        | — 2.30°               | 46                          |
| 10 | Light ... ..         | mean 0.79       | 0.9160                        | + 0.85°               | 55                          |

The lævo-rotation of Nos. 4 and 9 is due to the presence of a slightly larger amount of aromadendral than in the other samples.

The cineol was determined by the phosphoric acid method as carried out at that time, so that the amounts recorded in the table are naturally a little lower than would have been the case if the more modern methods had been adopted.

It will be observed that with Nos. 6 and 7, derived from general material, the characters were in close agreement, thus following the rule in this respect. The oil from abnormal leaves (No. 3) was of corresponding value, although it contained a little more pinene than that derived from older trees. Considering the results as a whole there was shown a fairly close agreement between the oils of the whole series, but identical results were only obtained with the two samples of oil from the same tree (No. 9).

The results of this investigation were published by us in the Proc. Roy. Soc., N.S.W., xxxi, 259.

## Leaf Material for Eucalyptus Oil Distillation.

### (a) FROM NATURALLY GROWING TREES.

THE most profitable species of Eucalyptus for oil production, considered from a commercial point of view, will be those which, both for yields and quality of oil, can stand the test of competition, so that naturally the continuity of supply enters very prominently into the question, particularly when a permanent plant has been erected.

In virgin forest country where the growth of Eucalyptus species has had free play, many of them, useful for oil production, acquire large dimensions, particularly species like *E. globulus*, *E. dealbata*, *E. Smithii*, *E. Macarthuri*, *E. citriodora*, &c. As only the leaves and terminal branchlets are required by the distiller, such large trees are naturally a disadvantage, the material having to be collected either by lopping off the branches or by felling the trees.\*

Opinion is divided as to which of the two methods is the most advantageous, and at one time considerable lopping of the branches from big trees was carried out. Lopping, however, is dangerous, and men are adverse to climbing tall trees for the purpose, although in Queensland the method is still adopted with *E. citriodora*.

More easy collection would naturally be obtained from the "coppice" growth which springs from the short remaining stems of the felled trees, and with many species this is rapidly produced and abundant.

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\* The bark of *E. Macarthuri* has, however, been employed for oil production.



**EUCALYPTUS DIVES.**

A BROAD-LEAF PEPPERMINT.

This species produces a different class of oil altogether to that from *E. Smithii*. Under favourable conditions the trees grow to a fair size, and have often been lopped for oil production. The rate of growth, both from the lopped and felled trees, is rapid, as can be seen from the following

PLATE XCI.

**EUCALYPTUS DIVES.**

Showing growth of leaves six months after the tree had been lopped,

PLATE XCII.

**EUCALYPTUS DIVES.**

Showing growth of leaves five months after the tree had been felled.

illustrations. One of these (Plate xci) represents a tree of this species, growing near Tarago, New South Wales, which had been lopped for oil distillation six months prior to taking the photograph; while the other (Plate xcii) shows the growth from the stump of a neighbouring tree, felled for the same purpose just five months prior to our visit to the locality.

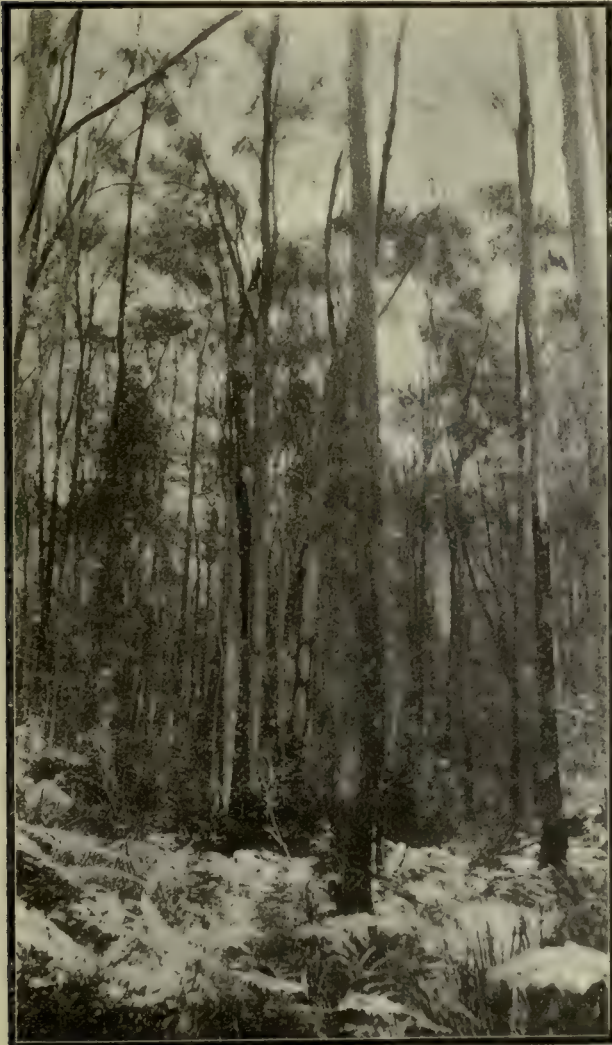


**EUCALYPTUS PHELLANDRA.**  
A NARROW-LEAF PEPPERMINT.

This is another species which shows great vitality and gives an abundance of new growth after the trees are felled. The oil is different in character to those of *E. Smithii* and *E. dives*. At certain localities this species grows quite gregariously, and is often practically the only Eucalypt over certain areas. This mode of growth is well shown in the accompanying illustration (Plate xciii), where all the trees in the picture are this species. The photograph was taken in Reedy Creek Gully, a few miles from Hill Top, New South Wales, where this Eucalypt was at one time extensively exploited for oil production, the trees being felled for the purpose.

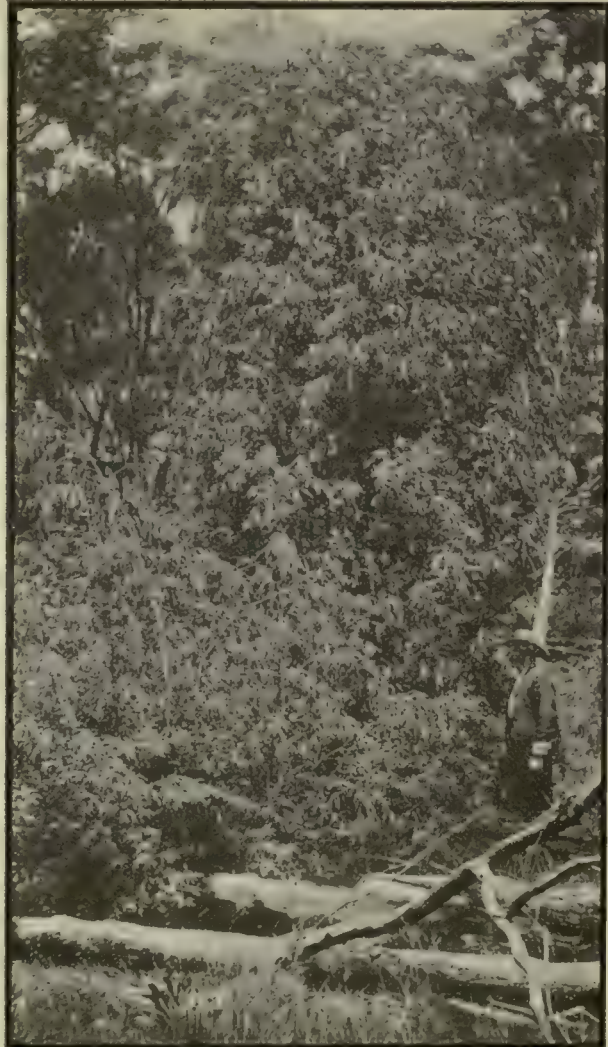
When we visited Reedy Creek two years after the trees were cut down, there was an abundance of young material growing from the stumps of the felled trees. Plate xciv will show how dense this growth had become, and how rapid it had been. The fallen logs are seen in the foreground of the picture.

PLATE XCIII.



**EUCALYPTUS PHELLANDRA.**  
A forest of "Narrow-leaf Peppermint," Reedy Creek Gully. Hill Top, New South Wales.

PLATE XCIV.



**EUCALYPTUS PHELLANDRA.**  
New growth from the stumps of the felled trees of this species, showing two years' growth.



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**EUCALYPTUS PHELLANDRA.**

A forest of "Narrow-leaf Peppermint," Reedy Creek Gully. Hill Top, New South Wales.

PLATE XCIV.

**EUCALYPTUS PHELLANDRA.**

New growth from the stumps of the felled trees of this species, showing two years' growth.



Reedy Creek, near Hill Top, extends for about 6 miles with branches and gullies in each direction, ranging from about  $1\frac{1}{2}$  to 3 miles long, in all about 20 miles, while the width varies from about 8 chains to 20 chains. The hills surrounding this valley are rocky and precipitous, but the district is well suited for the growth of this Eucalypt, country apparently of little use for any other purpose. At the time of our visit innumerable seedlings of this species were springing up in all directions.

Reedy Creek is a type of locality not uncommon in the mountain ranges of New South Wales, where oil-producing species, such as this, could be conserved most advantageously as natural plantations, so that a permanency of leaf material might be secured in the most economical manner.

#### THE MALLEES.

Eucalyptus species, however, do not all grow to a large size, the "Mallees" more particularly, and, for the reasons mentioned above, this shrubby growth is perhaps more useful for oil distillation than are the bigger species; besides several of the "Mallees" produce excellent cineol oils.

In certain portions of New South Wales, Victoria and South Australia, or, as a matter of fact, Australia generally, a considerable area of the country is covered with this shrubby Eucalyptus growth, which is known in Australia as "Mallee scrub." Several species occur in this "Mallee Belt," such as *E. polybractea*, *E. oleosa*, *E. Morrisii*, *E. dumosa*, *E. Behriana*, *E. viridis*, *E. cneorifolia*, &c., all of which have the form and growth peculiar to the "Mallees," that is several stems springing from one root.\* These species are usually found intermixed, some growing in one locality and some in another, but all have the same general appearance.

One of the best of the "Mallee" species, for oil distillation, is *E. polybractea*, known in Victoria as "Silver leaf Mallee," and in New South Wales as "Blue Mallee." In the Wyalong district of the latter State, as well as in the Inglewood district of Victoria, *E. polybractea* is extensively exploited for its oil, and much of the richer cineol Eucalyptus oil forwarded to Europe and America during the last few years has been derived from that Eucalypt. In South Australia, at Kangaroo Island, the species employed is *E. cneorifolia*, chiefly.

In the Wyalong district a considerable area of country is covered with "Mallee," and in some portions *E. polybractea* is present to the extent of from 40 to 50 per cent. of the total Eucalyptus growth. The material from the older trees of the "Blue Mallee" is not so useful for oil production as the younger growth, one reason being the yield of oil is not so great, and in order to secure an abundance of new leaf various devices have been adopted. One method is to employ a heavy roller and with this crush down the whole of the natural growth of the "Mallee Scrub." When the broken-down material becomes dry enough it is burnt off, all vegetation upon the ground being destroyed in the fire, but in a few weeks the young growth commences to appear in abundance, springing from the buried nodular root masses of the "Mallee," and in twelve to eighteen months is ready to be cut for oil distillation.

The abundance of new growth of the characteristic silvery leaf of this species, after this treatment, makes quite a pretty picture in the landscape, and is quite distinctive from the young growth of the other species.

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\* Photographs showing this form of growth will be found under *E. oleosa*, *E. polybractea*, and other species known as "Mallees."

The following series of photographs will serve to illustrate this method of working the "Mallee Scrub" in the Wyalong district of New South Wales, so that an abundance of new leaf may be produced, and also to free the country from certain objectionable growths common to the "Mallee" in its natural state.

Plate xcv represents the heavy roller and the way the material is broken down in preparation for burning off.

Plate xcvi shows the "face" of the "Mallee" still remaining, and also where the roller has passed along, crushing everything in its path.

PLATE XCV.



Roller used for crushing down the "Mallee" growth prior to burning off.

PLATE XCVI.



"Mallee" growth, showing path of the roller and the face of remaining "Mallee."

Plate xcvi, taken twelve months after the fire, shows the foliaceous growth which had taken place, and nearly the whole of the leaf shown in the picture is that of *E. polybractea*.

Although machinery has not yet been employed to cut and collect this new growth, yet it is thought that such a method of working should not be difficult, and it is proposed to endeavour to devise machinery to do this work, in order to minimise the initial cost of collection.



During the year 1919 large areas of the "Mallee Scrub" in the Wyalong district were being rolled and treated in this way, so that eventually abundant supplies of new leaf should be available there for oil distillation, and as the stills are modern in construction and of fair size, the establishment of an extensive Eucalyptus oil industry in the Wyalong district should be assured.

The chief species of "Mallee" growing in the "Mallee Belt" in the immediate neighbourhood of Wyalong, besides *E. polybractea*, are *E. Behriana*, *E. oleosa*, and *E. viridis*. The constitution of the oils, as well as the yields, from these Eucalypts, will be found recorded under the respective species in this work.\*

PLATE XCVII.



EUCALYPTUS POLYBRACTEA.

Showing new growth, twelve months after burning off the rolled "Mallee."

The above remarks in reference to *E. polybractea* and its associated species in New South Wales, are generally applicable to the conditions which obtain in the corresponding "Mallee Belt" in Victoria, where the Eucalyptus oil distilling industry is somewhat extensively carried on, and well established.

\* Another plant of common occurrence associated with *E. polybractea* is the "Broombush," *Melaleuca uncinata*. The oil of this *Melaleuca* is, in composition, very similar to that of "Cajuput," so well known in pharmacy, and might well be considered as an Australian "Cajuput."

(See Proc. Roy. Soc., N.S.W., December, 1907.)



The accompanying illustration (Plate xcviii) shows the method for procuring young material for distillation in the Bendigo district of Victoria.

The extension of the wheat areas in the Wyalong district is rapidly encroaching on the "Mallee," and much of it has already been destroyed, the land being utilised for agricultural purposes, and it seems that if portions of this natural vegetation, where the "Blue Mallee" grows most abundantly, are not conserved for the purpose of oil distillation, in a few years little material of *E. polybractea* will be procurable in the immediate neighbourhood of that town.

PLATE XCVIII.



*EUCALYPTUS POLYBRACTEA.*

Reproduction of young material for oil distillation, Bendigo district, Victoria.

In Kangaroo Island the "Mallee" *E. cneorifolia* is utilised for oil production to a considerable extent, and in a paper published in 1912 by Mr. H. J. Wiadrowski, an oil distiller on the island, it was shown that *E. cneorifolia* had, without any attention or cultivation, given a nett return of £3 per acre, and with a little effort to improve the leaf, it would be more profitable to conserve the "Mallee" for oil, than to work the land for grain, as the nett profits per acre would then be greater than from a 20-bushel crop of wheat at 3s. 6d. per bushel. This estimate was made at the time when Eucalyptus oil was very much cheaper than it is to-day.

#### (b) FROM CULTIVATED MATERIAL.

The illustrations given previously show how readily the oil-producing species renew their foliage, so that providing the necessary areas are conserved for the purpose of Eucalyptus oil production, abundant material for the preparation of certain classes of oils should be assured.

The "Peppermint" species, in the majority of cases, produce phellandrene oils together with piperitone, or cineol-phellandrene oils, and occasionally cineol oils without phellandrene. They grow most abundantly on the mountain ranges, and in country that probably will not be required for agricultural purposes, so that beyond the work needed for concentration in these areas, no further cultivation, with these species, need be considered.

With the perfumery oil-producing species, and to a lesser extent those yielding the richer cineol oils, the case is different, and it seems to us that the time is approaching when it will be necessary for certain species to be cultivated for their oils, if the increasing demands for these products is to be met in a satisfactory manner. Unfortunately the idea of systematically cultivating Australian plants for the production of their economics appears to have little interest for the average Australian, the tendency being rather towards the destruction of the native vegetation. The eventual shortage of supplies seems to have little influence, and this is evidenced in several directions.

So far little has been done in Australia in the direction of cultivation, and consequently accurate data in this connection, particularly with the oil-producing species, are limited.

#### EUCALYPTUS MACARTHURI.

Some evidence, however, is available, as a few acres were planted in September, 1911, at Emerald, Victoria, by Messrs. J. Bosisto & Co., with the geraniol and geranyl-acetate producing species, *E. Macarthuri*. The result from this effort was quite satisfactory, so much so, that recently a considerably extended area has been planted with the same species in the same locality.

PLATE XCIX



#### EUCALYPTUS MACARTHURI.

First plantation in Australia of *E. Macarthuri*, showing distilling plant in the foreground, Emerald, Victoria.

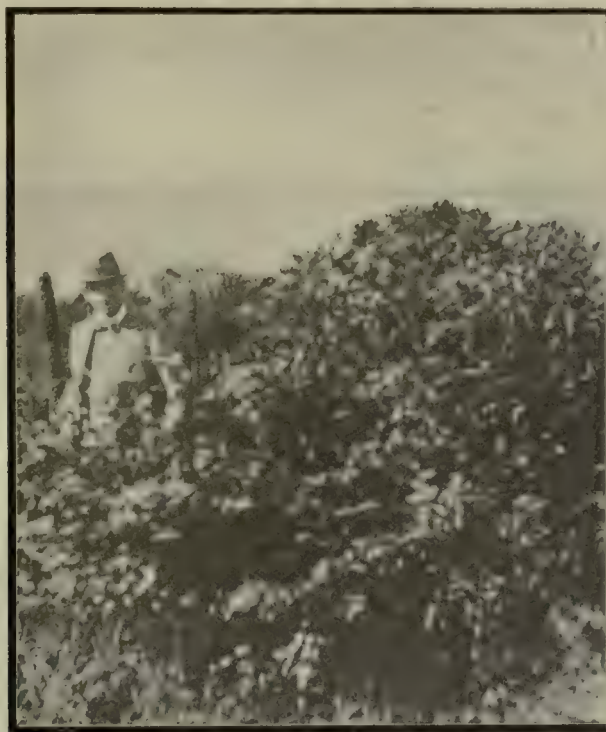
An illustration of this first plantation of *E. Macarthuri* is here given (Plate xcix), as being of interest in this connection. The still for the production of the oil is seen in the foreground.



*E. Macarthuri* grows quite well from seed, and the rapidity of growth and the vitality of the species are remarkable, so that a continuation of supply of leaf material for distillation from cultivated trees seems assured.

The rapidity of growth can be judged from the illustration (Plate c), which represents a shrub photographed 15 months after the seed was sown.

PLATE C.



**EUCALYPTUS MACARTHURI.**

Grown from seed at Emerald, Victoria. Fifteen months' growth.

A sample of the oil distilled from the clippings from bushes only 22 months old from the time of planting the seed, was presented to us by Mr. W. Russel Grimwade, of Melbourne. This oil on analysis was found to agree in general characters with that from naturally-grown material; it contained 70.1 per cent. of geranyl-acetate, saponifiable in the cold with two hours' contact, an amount of ester even greater than that usually found in the oil from old trees, and equal to that from the "suckers."

This result again supplies evidence as to the comparative constancy of the oil products of identical species of *Eucalyptus*, a factor of considerable importance when the cultivation of particular species of *Eucalyptus* is under consideration.

#### **EUCALYPTUS CITRIODORA**

It can also be demonstrated with other *Eucalyptus* species that the formation of their characteristic odoriferous constituents commences very early in the life history of the plant, and remains persistent throughout its whole growth. In the very early leaves of the seedlings of *E. citriodora*, for instance, the citronellal odour of the oil of this species can readily be detected, and this is also the case with other *Eucalypts*, the oils of which have a sufficiently distinctive odour.



In the gardens around Sydney trees of *E. citriodora* have been planted for ornamental purposes, and they grow very well in the Sydney soil and climate; but we know of no systematic attempt to cultivate this species for oil production. The investigation of the oil from the Sydney grown material showed it to be identical in general characters with that distilled from trees growing naturally in Queensland.

All the oil of *E. citriodora*, so far commercially obtained, has been distilled from trees in their native habitat, and as the species grows to a large size the difficulty of obtaining leaf material for distillation by lopping off the branches is apparent, although this method is followed to a considerable extent.

PLATE CI.

**EUCALYPTUS CITRIODORA.**

Climbing a tree, in order to procure leaves for distillation.

The accompanying photograph (Plate CI) shows the operator climbing the long, straight stem of the tree for the purpose of lopping off the branches in order to collect the leaves, and illustrates this laborious procedure very well. A tree of the same species is seen on the left of the picture.

The yield of oil from *E. citriodora* from naturally grown material is about 0.7 per cent. for leaves and terminal branchlets, and the product is in considerable demand and sells at a high price. The species thus gives promise of success if it were systematically cultivated, and it is evident that it must be more satisfactory to collect the material for distillation from cultivated plants than from big trees.

#### *EUCALYPTUS STAIGERIANA.*

This tree is also a Queensland species and yields an abundance of oil of quite a remarkable character for a Eucalyptus species, as it consists very largely of citral and limonene. The oil, in constitution, has thus quite a strong resemblance to lemon oil, and it seems reasonable to suppose, that when properly prepared for market it will become in favour as a flavouring agent, and in many ways take the place of lemon oil. Evidence is wanting as to its power of reproduction under cultivation, as it has not been planted to any extent in the Southern States. The species is, however, a very promising one, as the yield of oil is so great, and from cultivated material this should be produced at a lower price than lemon oil. The species may thus be considered as one of the many promising Eucalypts for essential oil production, and to be worthy of industrial effort in the direction of its cultivation.

### Cineol Oils.

THE present demand for the richer cineol Eucalyptus oils can be met very largely from species growing naturally in Australia, although for some time past the request for oils of this character has far exceeded the supply. The question of systematically cultivating the more promising species for cineol oil production, therefore, merits some consideration, in order to overcome certain disabilities at present operating, such as distance, distribution, and labour.

In countries outside Australia, *E. globulus* and a few other oil-yielding Eucalypts have been cultivated, primarily of course for timber, so that the oil produced from these trees has hardly been of much commercial importance. The best and most prolific oil-yielding species have not, until quite recently, attracted much attention in other countries, so that Eucalyptus oil production may be considered as essentially an Australian industry, the present position of which is such as to be considered worthy of every support.

#### *EUCALYPTUS SMITHII.*

The rapidity of growth shown by cultivated trees of some of the cineol oil-producing species is extraordinary, and this has often been pointed out, particularly with *E. globulus*. We have given some attention to this matter in connection with the excellent cineol oil-bearing species *E. Smithii*, and the results so far obtained are recorded herewith.

The natural habitat of this species is on the highlands, at an altitude of about 2000 to 3000 feet, and it might be thought perhaps that if planted at sea level, some differences in the rapidity of growth as well as in the composition of the oil might be observed. These changes, however, have not eventuated, as the results obtained with a cultivated tree, grown near Sydney, practically at sea-level, gave evidence of great stability in both directions.



In January, 1912, a seedling of *E. Smithii*, a few inches high, was brought from Hill Top and planted in a garden at Marrickville, near Sydney. The plant grew rapidly and in January, 1915, only three years afterwards, was 22 feet high with a very foliaceous head. In the following June the leaf portion of the tree was removed and distilled for oil (No. 1 in the list of analyses below). The foliage grew again very rapidly from the lopped stem, and in December, 1917, the tree was 25 feet high, and was as shown in the accompanying photograph (Plate CII). It was then felled to within 1 foot from the ground, the foliage being distilled for oil (No. 2 in list of analyses). After three weeks numerous shoots appeared springing from the short remaining stem, and at the end of March, 1918, this

PLATE CII.



PLATE CIII.



## EUCALYPTUS SMITHII.

Cultivated tree of *E. Smithii*, at Marrickville  
Growth after being lopped. Seedling planted  
January, 1912. Photo. taken December, 1917.  
This is the second head to the tree.

Same tree June, 1919, showing the fourth growth.  
The bush was then trimmed and the leaves distilled  
for oil. No. 4 in list of analyses.

growth was over 6 feet high, while in the middle of July it was 12 feet, two of the shoots reaching that height; three of the stems were  $3\frac{1}{2}$  inches in circumference at 3 inches above the attachment with the main stem; three more were 3 inches in circumference, and from twenty to thirty other shoots, all bearing leaves in profusion. On the 1st January, 1919, some of the shoots had stems up to 6 inches in circumference, and three of them had grown to 15 feet in height in the twelve months. The tree was then cut down to within 3 or 4 inches of the main stem, and the leaves distilled for oil (No. 3 in list of analyses). In about three weeks innumerable shoots again appeared, and by the beginning of June, 1919, some of these had reached a height of 9 feet. The tree at that time had the appearance shown in the illustration (Plate CIII).



The tree was then trimmed into the form of a small bush under 6 feet high, the trimmings being distilled for oil (No. 4 in list of analyses). The bush again grew rapidly, and in the middle of October, 1919, had reached a height of 13 feet, having grown about 7 feet in height during the four months. The appearance at that time is shown in Plate CIV. It was again trimmed into bush form and the material removed distilled for oil (No. 5 in list of analyses). The results of these analyses are thus of interest, because of the varying ages of growth of the leaves, and the constancy of the oil products.

PLATE CIV.

**EUCALYPTUS SMITHII.**

Cultivated at Marrickville, near Sydney. Photograph taken prior to trimming, October, 1919. No. 5 in list of analyses.

In the table (p. 444), No. 6 gives the analysis of the oil distilled from material taken from a tree cultivated at Ashfield, near Sydney, by Mr. E. Cheel, from seed collected by him at Mount Jellore, October, 1915. (See Proc. Roy. Soc., N.S.W., 1916, abstracts, p. 24.) It will be seen that the characters of the oil from this tree are in agreement with those from the tree grown at Marrickville.

The data given supplies fresh evidence as to the value of the oil of this species, as well as illustrating its rapid growth and vitality, and also its ready response to cultivation. The foliaceous nature of the tree, the somewhat large yield of oil, together with its high cineol content, all suggest the possibility of profitable returns from cultivated trees of *E. Smithii*.

One advantage to be derived from material so grown would be the uniformity in the character of the oil produced, as the mixing of leaves from other species would be avoided.

TABLE OF ANALYSES OF THE CRUDE OILS OF CULTIVATED MATERIAL OF EUCALYPTUS SMITHII.

| No., age of tree, and date of felling.                                | Specific gravity at 15° C. | Optical rotation $\alpha_D$ | Refractive index at 20° C. | Solubility in 70 per cent. alcohol. | Cineol, per cent. by the Resorcinol method. | Yield of oil per cent. |
|-----------------------------------------------------------------------|----------------------------|-----------------------------|----------------------------|-------------------------------------|---------------------------------------------|------------------------|
|                                                                       |                            |                             |                            | Volumes.                            |                                             |                        |
| 1. Tree planted, Jan., 1912, lopped, June, 1915. 22 ft. high.         | 0.9198                     | + 4.7°                      | 1.4672                     | 1.2                                 | 75                                          | 1.4                    |
| 2. Tree felled, Dec., 1917. 25 ft. high.                              | 0.9161                     | + 6.4°                      | 1.4651                     | 1.2                                 | 73                                          | 1.9                    |
| 3. Tree again felled, 1st Jan., 1919. 15 ft. high.                    | 0.9165                     | + 6.2°                      | 1.4637                     | 1.2                                 | 75                                          | 1.8                    |
| 4. Bush trimmed, 14th June, 1919, to under 6 ft. high.                | 0.9154                     | + 5.2°                      | 1.4622                     | 1.1                                 | 74                                          | 2.2                    |
| 5. Bush again trimmed, 18th Oct., 1919.                               | 0.9160                     | + 4.8°                      | 1.4616                     | 1.1                                 | 77                                          | 2.0                    |
| 6. Tree cultivated at Ashfield, by Mr. Cheel; leaves cut, Oct., 1919. | 0.9192                     | + 5.6°                      | 1.4616                     | 1.1                                 | 77                                          | 2.0                    |

## Extraction of Eucalyptus Oil in Australia.

EUCALYPTUS oil can be distilled from the leaves without difficulty by a simple method of steam distillation, together with a satisfactory condensing arrangement, and this procedure alone is sufficient for the preparation of the crude product. In the still erected for our own use the steam was generated in a separate boiler, and passed into the digester in which the leaves were packed, the pressure of steam in the chamber not usually exceeding 10 pounds at any time. Condensation was assured, so that the total oil obtainable from the leaves of the species was secured. The material was carefully weighed before being placed in the digester, and the weight of the oil determined to the nearest half-ounce. The leaves and terminal branchlets were used in all instances as would be done if collected for commercial distillation.

A first consideration from the oil distillers' point of view is the water supply. In the mountain ranges where the "Peppermint" Eucalyptus species abound, water is fairly abundant, but in the "Mallee" country this is not so, and the question of water for distillation becomes of considerable importance, the annual rainfall over the "Mallee" country being between 10 and 20 inches. Fortunately the water-holding capacity of the ground in the "Mallee" country is very good, so that it is not difficult to store the rain water by the erection of dams. This method of conserving the water in quantity is shown in

the accompanying photograph (Plate cv), which represents the Shire Dam at Buddigower, near Wyalong, New South Wales. The photograph was taken towards the end of 1919, during the very severe drought of that year, and at the time when most of the smaller dams had dried up.

PLATE CV.



THE BUDDIGOWER DAM.  
Near Wyalong, New South Wales.

The larger Eucalyptus oil distilleries in the "Mallee" country in Victoria have provided themselves with an abundant supply of water by similar methods.

As Eucalyptus oil is so easily distilled, and the leaf material not difficult to collect, it is only natural that very crude apparatus is sometimes employed, although with the more advanced distilleries, quite expensive and up-to-date steam-distilling plants are in operation. The consideration of the erection of a permanent plant of large capacity is, of course, a matter of ways and means, depending also on the available supply of leaf.

Eucalyptus species mostly grow intermixed, and it is only in rare instances that a particular species is found predominating over an area of country to any great extent, so that if energetically worked for oil production the species may soon be cut out in close proximity to a permanent plant of large dimension. For this and other reasons, it has, in certain cases, been considered advantageous to erect mobile distilling plants, which are removable without difficulty to fresh localities,



Most Eucalypts are very tenacious of life, and new growth soon springs from the stumps of the trees cut down, so that it is only a matter of a comparatively short period before fresh material is again available, and usually in greater abundance than was the case originally. Instances of this rapid reproduction may be seen from the illustrations already given in this work.

We have previously shown that the oil obtainable from this young growth is of the same character as that from the mature leaves, so that little difference in the quality of the oil will be observed. If then the areas be sufficiently extensive, the supply of material for oil distillation will be continuous, and a permanent plant an advantage if security of occupation is assured. Considerations respecting the continuity of supply of leaf material and of cultivation have been dealt with in a previous article.

#### EUCALYPTUS OIL DISTILLING PLANTS AND THEIR CONSTRUCTION.

In the smaller distilling plants, in New South Wales particularly, it has become customary to generate the steam in the vessel in which the leaves are packed. A very general method is to employ one or more of the common square 400-gallon iron tanks, to insert a grating of some kind at about 8 inches from the bottom to support the leaves, and to fill the space below with water. The tanks are placed upon a suitable foundation and the fires lighted below. When the water boils the steam passes through the leaves, carrying the oil with it. The condenser and still attachments take various forms, but all are constructed with some regard to the main principles of condensation. In the more simply constructed plants, particularly in localities where water is abundant, the condensation is brought about by laying a sufficient length of pipe from the still, in a running stream if possible, bending the end of the pipe outwards through some protection, and collecting the condensed water and oil in a receiver in which the oil separates, and is drawn off either automatically or otherwise.

In simple distilling plants of this nature no provision is usually made for unloading the spent leaves by mechanical means, this operation being performed by manual labour, so that, with a still of this description, it is evident that a minimum of result is obtained with a maximum of effort; but this primitive method of distillation will continue to be employed because the plant is cheap, easily dismantled for removal, and can be worked by one or two men, by families, or by small communities.

The lid attachments to these tank stills are made in various ways, the most common being to remove the top, and rivet a right-angled flange around the outside. The lid is a flat sheet of iron, and between this and the flat surface of the flange the joint is made, by inserting packing of some sort, either with clay or without, and fastening the whole with stout steel clips. Another method is to have the flange turned inwards, and to fasten stirrups on the outside of the tank. The lid is a flat sheet of iron in this case also, and the joint made steam-tight in the usual way and fastened tightly by the aid of wedges.

It was considered at one time that the correct arrangement for a Eucalyptus oil still must include a copper still-head, to allow of easy exit of the steam from the tank to the condenser, but in the majority of cases this copper outlet is now discarded, as it was found to be unnecessary and costly. It must be remembered, too, that in nearly every case Eucalyptus oils contain free acid, and this, when present in sufficient amount, attacks the copper, the dissolved portion being conveyed into the oil, giving it a green colour. How

injurious this may be is seen from the results we have recorded under *E. cinerea*. The outlet for the steam is now made in a simple manner by inserting a 2 or 3 inch iron pipe through the side of the tank just below the top. No difficulty is experienced, and practically all the oil is obtained from the leaves in this way.

#### ILLUSTRATIONS.

The following series of plates will serve to illustrate the various forms of Eucalyptus oil stills in operation in Australia; from the single tank, where direct firing is employed, to the larger installations worked with boiler and separate digesters. In many of the more modern and larger plants the digesters are sunk in the ground, and are constructed either of wood or of iron. This method allows of easy loading and unloading, and works quite satisfactorily.

We are indebted to the proprietors of these distilleries for much information concerning their construction.

PLATE No. 106. Single tank Eucalyptus oil still at Springgrove, near Braidwood, New South Wales. It is of double size, and fired directly. Three men were working this plant, mutually performing the necessary duties such as cutting the leaves, carting, and distilling. The species being worked were the "Narrow-leaf" and "Broad-leaf Peppermints," *E. phellandra* and *E. dives*, and from 75 to 80 pounds of oil were obtained at each distillation. The value of this crude oil at the stills in November, 1919, was 7½d. per pound, so that good wages can be secured with a simple plant of this description. The tank shows the stirrup form of fastening on the lid, and two straight pipes, laid in water, for condensing the steam. (Mr. A. J. Bedwell.)

PLATE No. 107. The more common type of still in which two tanks are coupled together and fired directly. The condensing arrangement is usually the long straight 2-inch iron pipe, and the cover is fastened with steel clips. These stills are usually employed in New South Wales for working the "Peppermint" species. (Mr. McGrath.)

PLATE No. 108. The arrangement of three directly fired tanks linked together. In this plant either one, two, or three tanks could be worked at the same time. The condenser was fixed in a similar tank at the rear, into which the water was pumped from a creek running near the tree.\* (Australian Eucalyptus Oil Co.)

PLATE No. 109. Four square tanks linked together and worked with a boiler. This plant was in operation at Wyalong, New South Wales, distilling *E. polybractea*. The yield of oil from this species is less than from either the "Narrow" or "Broad-leaf Peppermint," consequently the value of the oil at the stills is greater than that of the crude phellandrene-bearing "Peppermint" oils. (Wattle Brand Eucalyptus Oil Co.)

PLATE No. 110. A plant in operation on the Cygnet River, Kangaroo Island, South Australia. The species being worked were *E. cneoriifolia* and *E. odorata*. The distillation was carried out by direct firing, the tank being a large one, holding about 4,000 pounds of partly dried leaves, or 5,000 pounds of green leaves with terminal branchlets. The bottom part was set in bricks, the upper

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\* The tree close to where the man and boy are standing is *E. Macarthuri*, the species from which the oil so rich in geranyl-acetate is obtained.



part framed with wood. The distillation was continued for three hours, and during the spring and summer months about 112 pounds of oil were obtained from each charge. In the winter months the yield was only about half that amount. By the mechanical means adopted the whole of the spent leaves could be lifted out under six minutes from the time the lid was removed. (Mr. E. Burgess.)

PLATE No. III. A crude adaptation of the principle of distillation, where the steam is produced outside the digester. The whole plant consisted of three 400-gallon iron tanks; one of these was used as a boiler, another as the digester, while the third was the condenser. The worm for condensing the steam was of copper and the large still-head was also of copper. This plant was working at Macedon, Victoria, distilling the "Peppermint" species. (Mr. Saddington.)

PLATE No. II2. Another plant working at Macedon, Victoria, also distilling the "Peppermint" species. The steam was produced by a small boiler and the digesters were two 400-gallon tanks, worked alternately, so that by preparing one tank while the other was being distilled the process could be made continuous. The water was supplied to the condenser by the aid of the windmill. (Mr. Tovey.)

PLATE No. II3. A plant at Huntley North, Victoria. The species being worked was *E. polybractea*. The digester was constructed of wood and was 8 feet by 5 feet 9 inches. The condenser was made of copper. (Mr. Moyles.)

PLATE No. II4. A plant at Wyalong, New South Wales, employed in distilling *E. polybractea*. The three digesters were of iron, sunk in the ground, one holding about 2,500 pounds of leaf material, the others a little smaller. A large Cornish boiler supplied the steam, the working pressure being 30 to 35 pounds, and the time of distillation two hours. The spent leaves were removed by mechanical means. (Gillard Gordon, Ltd.)

PLATE No. II5. A plant working *E. polybractea*, at Wyalong, New South Wales. There were two digesters sunk in the ground, the larger holding about 3,000 pounds of leaf material. When in full working order six digesters were distilled each day, the time for each being two hours. (Gillard Gordon, Ltd.)

PLATE No. II6. A large plant at Whirrakee, near Bendigo, Victoria. The two large digesters were built of wood, bound with iron, and sunk in the ground. The lid was of wood also, with an outlet in the centre made of copper. The digesters were 12 feet deep with a diameter of 6 feet 6 inches, and held about 8,000 pounds of leaf material. The best yield of oil was about 160 pounds for each digester, although in the winter the yield was only about half that amount. The condenser was laid in a concrete trench with about 260 feet of piping, from 3 inches in diameter, diminishing to 1½ inches. The boiler was a large Cornish one, 22 feet long, and much of the spent leaf material was burnt in it. The crude oil was refined by steam distillation in the ordinary way. The chief species worked was *E. polybractea*. (The Hardinge Smith Co-operation Ltd.)



PLATE No. 117. A large plant at Huntley North, Victoria, for distilling the "Mallee" species. The two digesters, built of wood, were 7 feet 6 inches deep, by 5 feet 6 inches in diameter, and sunk in the ground. A large tubular boiler supplied the steam, the pressure being 15 to 20 pounds. The oil was rectified by steam. (Mr. J. M. Hodgson.)

PLATE No. 118. A Victorian distilling plant for the production of Eucalyptus oil. Each of the four digesters was of 2,000 gallons capacity. (Messrs. J. Bosisto & Co.)

PLATE No. 119. A distilling plant at one time working at Punyelroo, on the River Murray in South Australia. The digesters, one of which is shown in the picture, had a capacity of between 4,000 and 5,000 gallons. One of them was a brewer's fermenting vat, and the other built of pine, with the fittings of copper. (Messrs. Faulding & Co.)

We have selected this series of plates as they give a very good summary of the several methods employed in the production of Eucalyptus oil in Australia. In an undertaking of this character, where some hundreds of stills of one kind or another are in operation, it is to be expected that a considerable diversity in general ideas will be evident, but we think the range of stills here illustrated is sufficiently comprehensive to cover the majority of those employed in the industry.

PLATE CVI.



SINGLE TANK, EUCALYPTUS OIL STILL, DIRECT FIRING.  
Spring Grove, near Braidwood, N.S.W. (M. A. J. Bedwell.)



TWO-TANK EUCALYPTUS OIL STILL, DIRECT FIRING.  
Youri, N.S.W. (Mr. McGrath.)



Photo.]

THREE-TANK EUCALYPTUS OIL STILL, DIRECT FIRING.  
Wingello, N.S.W. (Australian Eucalyptus Oil Co.)

[M. F. Connelly,



PLATE CIX.



FOUR-TANK EUCALYPTUS OIL STILL, STEAM FROM BOILER.  
Wyalong, N.S.W. (Wattle Brand Eucalyptus Oil Co.)

PLATE CX.



EUCALYPTUS OIL STILL, DIRECT FIRING.  
Kangaroo Island, South Australia. (Mr. E. Burgess.)





COMPOSITE EUCALYPTUS OIL STILL, USING THREE TANKS.  
Macedon, Victoria. (Mr. Saddington.)



EUCALPYTUS OIL STILL, WITH SQUARE TANK DIGESTERS, STEAM FROM A BOILER,  
Macedon, Victoria. (Mr. Tovey.)



EUCALYPTUS OIL STILL, WITH WOODEN DIGESTER.  
Huntley North, Victoria. (Mr. Moyles.)



EUCALYPTUS OIL STILL, WITH THREE IRON DIGESTERS SUNK IN THE GROUND.  
Wyalong, N.S.W. (Messrs. Gillard Gordon, Ltd.)

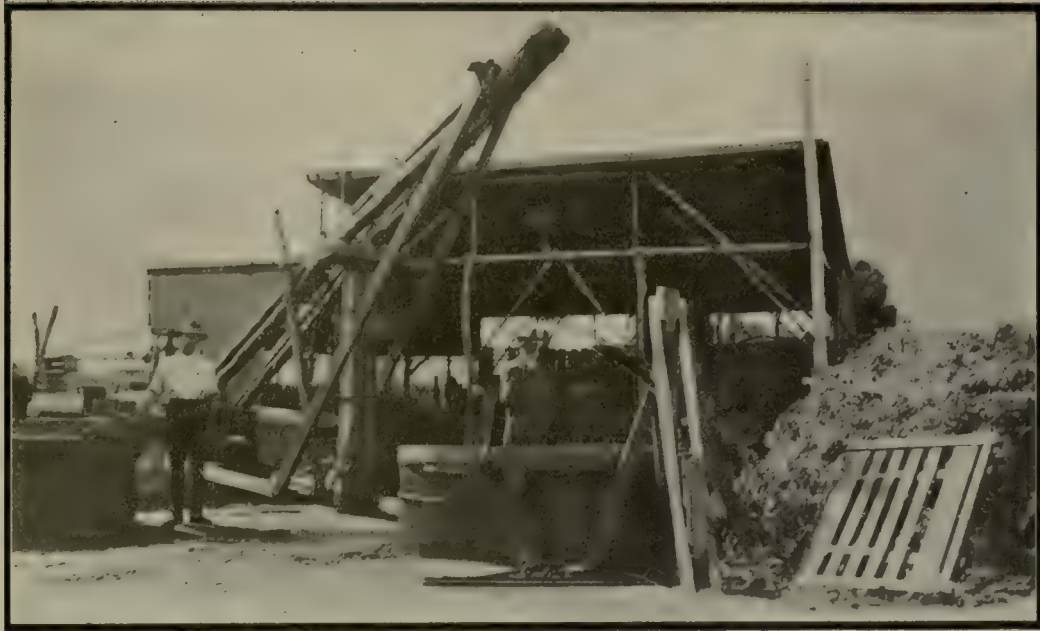


EUCALYPTUS OIL STILL, WITH TWO IRON DIGESTERS SUNK  
IN THE GROUND.

Wyalong, N.S.W. (Messrs. Gillard Gordon, Ltd.)



PLATE CXVI.



EUCALYPTUS OIL STILL, WITH TWO LARGE WOODEN DIGESTERS  
SUNK IN THE GROUND.  
Whirrakee, Victoria. (Hardinge Smith Co-operation.)

PLATE CXVII.



EUCALYPTUS OIL STILL, WITH TWO LARGE WOODEN DIGESTERS  
SUNK IN THE GROUND.  
Huntley North, Victoria. (Mr. J. M. Hodgson.)



EUCALYPTUS OIL STILL.  
Victoria. (Messrs. J. Bosisto & Co.)



EUCALYPTUS OIL STILL.  
South Australia. (Messrs. Faulding & Co.)

A

PLATE CXX.



A

*E. vernicosa.*

4000 FEET ABOVE SEA  
LEVEL ON THE HARTZ  
MOUNTAINS.

LEAVES CARRIED  
2 MILES.

B

THE LEAVES WERE THEN  
"PACKED" 12 MILES TO  
GEEVESTON, THENCE BY  
BOAT TO HOBART AND  
SYDNEY.

2 CWT. TO THE LOAD.



C

*E. Perriniana.*

LEAVES BEING DRAWN 12  
MILES TO OUSE BRIDGE,  
THEN 25 MILES BY  
HORSE-TEAM TO MAC-  
QUARIE PLAINS, THENCE  
BY TRAIN TO HOBART  
AND BOAT TO SYDNEY



# COLLECTING EUCALYPTUS LEAVES IN TASMANIA.

Supervised by Mr. L. G. Irby, Conservator of Forests, Tasmania.



## Commercial Applications of Eucalyptus Oils.

THE various types of Eucalyptus oils find employment in many ways, and new uses for them are frequently being discovered. The industry to-day has reached very fair dimensions in Australia, and the outlook for the future utilisation of these oils in new branches of manufacture is most promising.

It is not generally known, however, that among the first natural raw products exported from Australia was Eucalyptus oil. In the "Journal of a Voyage to New South Wales," by John White, Esq., Surgeon-General to the Settlement, and published in London, 1790, is this statement in the appendix, p. 227 :—"The name of 'Peppermint Tree' has been given to this plant by Mr. White on account of the very great resemblance between the essential oil drawn from its leaves and that obtained from the 'Peppermint' (*Mentha piperita*) which grows in England. This oil was found by Mr. White to be much more efficacious in removing all cholicky complaints than that of the English 'Peppermint,' which he attributes to its being less pungent and more aromatic. A quart of the oil has been sent by him to Mr. Wilson."

The above, written by Dr. J. E. Smith (founder of the Linnean Society) shows, we think, that the credit for being the first to produce and use Eucalyptus oil therapeutically was Surgeon-General White, and to him thus belongs the honour of founding the Eucalyptus oil industry.

Mr. Maiden, however, gives the credit to Surgeon Considen, when naming a species after that gentleman, Proc. Linn. Soc., N.S.W., Vol. 29, 1904, p. 477.

In Considen's letter to Sir Joseph Banks, dated Port Jackson, 18th November, 1788, and published in the Historical Records of New South Wales, Vol. I, part II, p. 220, is found the following paragraph in this connection :—

"This country produces a variety of flowers and shrubs totally unknown in Europe, and five or six species of wild myrtle, some of which I have sent to you dried. An infusion of the leaves of one sort is a mild and safe astringent in the treatment of dysentery. We have a large peppermint tree, which is equal, if not superior, to our English peppermint. I have sent you a specimen of it. If there is any merit in applying these and many other simples to the benefit of the poor wretches here, I certainly claim it, being the first who discovered and recommended them."

It seems to us that Considen worked on the native plants mentioned in other directions, at any rate, he makes no claim whatever for the oil, nor is the word oil mentioned in his letter. Unless further evidence is produced, it is difficult to see how Considen can be acclaimed as the founder of the Eucalyptus oil industry.

Among Sir Joseph Banks' papers, dated 17th November, 1789, reference is also made to a bottle of Eucalyptus oil which had been forwarded to him by Governor Phillip in the ship "Golden Grove," together with other exhibits, but there appears to be no evidence that Considen was interested in this. (See footnote, Records N.S.W., Vol. I, part II, p. 283.)

(a) **For Pharmaceutical Purposes.**—The species from which the first sample of Eucalyptus oil had been distilled was *E. piperita*, and this Eucalypt gives a product consisting of phellandrene, piperitone, cineol and some minor constituents.

It is worthy of mention that the Eucalyptus oil industry was established in Australia on oils of this class. It was in 1853 that Baron von Mueller recommended the distillation of Eucalyptus oil, and he claims this in his "Extra Tropical Plants," under *E. amygdalina*. In 1854 Mr. J. Bosisto established, in Victoria, the first factory for the commercial distillation of Eucalyptus oil in Australia, the species utilised being chiefly the one known at that time as *E. amygdalina*. The oil of that species contained phellandrene, piperitone and cineol, and in constitution had some resemblance to that of *E. piperita*.

As the more pronounced cineol bearing Eucalyptus oils became in request, those containing phellandrene receded in favour, and to meet this demand the "Mallee" oils came into prominence, while in Tasmania the chief species employed was *E. globulus*. The "Mallee" oils, being as a rule more closely related to the "Boxes," have, in most cases, distinctive properties from those of the *E. globulus* type, in that they contain the aldehyde aromadendral, a constituent which has been shown by Dr. Cuthbert Hall and others to have five or six times the bactericidal value of cineol.

The demand at present for medicinal oils is mostly for those having a high cineol content, and the United States Pharmacopœia demands a minimum of 70 per cent. of that constituent; but, as can be seen from the results recorded in this work, only a comparatively few species yield oils of this character in sufficient amount to be profitable for distilling at the usual price paid for cineol oils, and for that reason the demand for those containing 70 to 80 per cent. of cineol has, for some time past, far exceeded the supply.\*

The British Pharmacopœia's standard is more reasonable, only requiring 55 per cent. of cineol. For the supply of oils of this quality Australia has numerous species, as can be seen by referring to the lists under Group III, class (b), and group IV, class (a).

The question, however, is not yet settled as to whether cineol is the most valuable medicinal constituent in Eucalyptus oils, and Dr. Atfield directs attention to this uncertainty in his work on Chemistry (p. 505). Mr. E. M. Holmes (Pharm. Journ. III, 25, p. 501) says that "the chemistry is far in advance of the therapeutic and physiological knowledge of Eucalyptus oils."

In connection with this question an investigation on the bactericidal value of the several constituents of Eucalyptus oils was undertaken by Dr. Cuthbert Hall, of Parramatta, in 1904; these results were published privately.

Considerations respecting the therapeutic value of Eucalyptus oils are beyond the scope of this work, but much information may be found scattered throughout the various scientific and pharmaceutical publications.

Such a large number of constituents occur in oils of the various Eucalypts, that it may be the medicinal value of Eucalyptus oil is more largely due to the admixture of certain of these, than to that of any one individual constituent.

(b) **For Mineral Separation.**—As with cineol, other constituents which contain oxygen, such as citronellal, piperitone, aromadendral, geranyl-acetate, &c., as well as the several terpenes, reach a maximum in the oils of particular species of their class, and by taking advantage of this peculiarity, and exploiting those species which contain the desired constituent in greatest abundance, these products are now, or may eventually become, articles of commerce.

\* Commercially pure cineol is now manufactured in Australia, and can be supplied in any reasonable quantity if it is desired to use the pure product in preference to the oils.



One very important use to which the phellandrene-piperitone Eucalyptus oils are put is in the separation of metallic sulphides from the gangue, by a flotation process. The use of Eucalyptus oil for this purpose was discovered by Mr. Henry Lavers at Broken Hill, New South Wales, and this is shown in the following claim, made by Mr. J. Ballat, the Chairman of Directors, at a meeting of Minerals Separation Ltd., held in London in December, 1910.

"In Australia a member of our staff there (Mr. Henry Lavers) discovered that certain of the Eucalyptus oils are eminently suitable for the purpose. Less than a pound of this reagent is all that is required to recover the values from a ton of ore. This reagent and process have been properly protected under patents the world over. These processes are ours, and I trust they will be profitable to us . . . and to Australia in particular, by turning part of her vast forests of Eucalyptus to profitable account."

The oils from specific species for these experiments were supplied by this Museum.

Since that time very large quantities of oil have been distilled from the "Peppermint" species, both in New South Wales and Victoria, and used for flotation work. *E. dives*, a "Broad-leaved Peppermint," is generally recognised as yielding the best oil for this purpose, and consequently the product of this Eucalypt is in much request.

This species, together with the "Narrow leaf Peppermint" *E. phellandra*, has an extensive range in the States above mentioned, and is particularly abundant at certain localities in the mountain ranges at an altitude of about 1,500 to 3,000 feet. As this particular oil is such a useful article of commerce, and contains piperitone in quantity, it should be good policy to conserve the species (*E. dives*) for oil production, in those localities where it grows most luxuriantly, more particularly as the "Peppermint" Eucalypts are generally found on poor soil and in mountainous country, not likely to be in much demand for agricultural purposes.

Through the kindness of Mr. A. J. Bedwell, we are able to give the following results as to the flotation efficiency of the oils of *E. dives* and of *E. phellandra*, the "Narrow leaf Peppermint." Ordinary material of *E. dives* was distilled by Mr. W. St. Clair, near Colombo, New South Wales, a square tank with direct firing being used, and the oil collected each hour for eight hours. After we had determined the constants, the oils were forwarded to Mr. Henry Lavers, who ascertained their values for flotation work. The results he obtained are given in column five.

#### EUCALYPTUS DIVES.

| Oil collected during— |     |     | Specific gravity at<br>15° C. | Rotation $\alpha_D$ . | Refractive index at<br>20° C. | Flotation<br>efficiency. |
|-----------------------|-----|-----|-------------------------------|-----------------------|-------------------------------|--------------------------|
| First hour...         | ... | ... | 0.8835                        | — 65.7°               | 1.4791                        | 98.1                     |
| Second hour           | ..  | ... | 0.8913                        | — 64.2°               | 1.4801                        | 99.8                     |
| Third hour...         | ... | ... | 0.8932                        | — 63.0°               | 1.4799                        | 102.2                    |
| Fourth hour           | ... | ... | 0.8981                        | — 64.5°               | 1.4810                        | 102.1                    |
| Fifth hour...         | ... | ... | 0.9040                        | — 60.0°               | 1.4821                        | 100.3                    |
| Sixth hour...         | ... | ... | 0.9116                        | — 56.2°               | 1.4828                        | 104.2                    |
| Seventh hour          | ... | ... | 0.9113                        | — 55.3°               | 1.4831                        | 99.4                     |
| Eighth hour           | ... | ... | 0.9130                        | — 53.6°               | 1.4832                        | 102.2                    |



From this table the high flotation efficiency of the oil of this species is evident, and is superior to that of other Eucalyptus oils, although the product of *E. phellandra* is but little inferior for the purpose.

The following tabulated results are from the oil of *E. phellandra*, the "Narrow leaf Peppermint," distilled at Mongarlowe, New South Wales, by Mr. F. Webb. Ordinary material was used, and the distillation carried out by the usual square tank with direct firing. The flotation efficiency results were determined by Mr. H. Lavers, the standard being that of *E. dives* taken as 100.

#### EUCALYPTUS PHELLANDRA.

| Oil collected during— | Specific gravity<br>at 15° C. | Rotation $\alpha_D$ . | Refractive index<br>at 20° C. | Cineol,<br>per cent. | Flotation<br>efficiency. |
|-----------------------|-------------------------------|-----------------------|-------------------------------|----------------------|--------------------------|
| First hour... ..      | 0.9100                        | — 5.9°                | 1.4616                        | 45                   | 84.4                     |
| Second hour ... ..    | 0.9110                        | — 6.2°                | 1.4634                        | 40                   | 74.8                     |
| Third hour ... ..     | 0.9087                        | — 7.4°                | 1.4660                        | 15 to 18             | 92.2                     |
| Fourth hour ... ..    | 0.9085                        | — 8.0°                | 1.4677                        | about 10             | 90.9                     |
| Fifth hour ... ..     | 0.9095                        | — 8.0°                | 1.4678                        | 5 to 7               | 95.5                     |
| Sixth hour ... ..     | 0.9083                        | — 8.5°                | 1.4685                        | .....                | 85.3                     |
| Seventh hour ... ..   | 0.9079                        | — 8.5°                | 1.4690                        | .....                | 93.0                     |
| Eighth hour ... ..    | 0.9085                        | — 8.6°                | 1.4716                        | .....                | 87.9                     |

The cineol diminished in amount as the time of distillation proceeded, but phellandrene was present in fair amount in all the samples.

(c) **For Perfumery Purposes.**—Another important direction in which certain Eucalyptus oils are now employed is in the perfumery industry, for scenting soaps, and for similar purposes.

One of the most frequently occurring constituents in Eucalyptus oils is the acetic acid ester of geraniol, usually associated with the free alcohol. Like all other constituents occurring in Eucalyptus oils, geranyl-acetate reaches a maximum in one species, in this case *E. Macarthuri*, where it is found in both the leaves and the bark. This Eucalypt probably supplies the only instance on record where geraniol occurs in the bark of a big tree in sufficient quantity to permit of its extraction on a commercial scale, and is another illustration of the diverse nature of the oil products obtainable from the genus.

This diversity in constitution is also illustrated with the product of *E. citriodora*, a species which yields an oil consisting almost entirely of the aldehyde citronellal. This oil is in considerable request for perfumery purposes and is employed for the production of the corresponding alcohol citronellol, which substance has even a more pronounced rose odour than has geraniol.

The aldehyde citral also occurs in the oils of a few species, most abundantly in that of *E. Staigeriana*.

Other odoriferous constituents are the ketone piperitone, a commonly occurring substance in the oils of the "Peppermints"; and the aldehyde aromadendral which is present in those of the typical "Boxes" and associated "Gums." The former constituent is found in quantity in the oil of *E. dives* and other species, and the latter in those of *E. salubris*, *E. hemiphloia*, *E. rostrata* and oils of that class.

The second and third hour oils of *E. Australiana* should also be of value for perfumery purposes, as they contain terpineol and geraniol as well as esters. Terpineol like geraniol is a common constituent in Eucalyptus oils.

(d) **Other Uses.**—Besides the applications enumerated above, the various Eucalyptus oils are utilised in other directions, and find employment in the manufacture of a large number of proprietary articles, as well as in the soap-making industry, the preparation of disinfectants, and as solvents.

As far back as 1862 a number of experiments were undertaken to determine the value of Eucalyptus oils as solvents for resins, and a table is published in the *Technologist*, 1863, p. 13, giving a list of these results. Experiments were also carried out at that time to investigate their use for illumination instead of kerosene, and with considerable success.

As illustrating the possibility of manufacturing new products from various Eucalyptus oil constituents, piperitone may be mentioned; this ketone occurs so abundantly in the oils of some species, *E. dives* particularly, that it could be supplied in tons if required, consequently it can be produced at a comparatively low price. It has been shown that thymol can readily be manufactured from it, and menthone also, consequently it should not be a very difficult problem to produce menthol in commercial quantities from Eucalyptus oil.

This result is an illustration of the economic possibilities which the constituents of Eucalyptus oils offer for scientific research, and for manufacturing purposes. (See also the article on piperitone in this work.)

The economic use to which the water remaining in the tanks and digesters, after the leaves have been distilled, might also be mentioned. This residual water contains a considerable amount of tannin and other substances extracted during the distillation, and has been found a useful substance for the prevention of scale in boilers. At some of the distilleries this water is concentrated by evaporation, and placed on the market in that condition.

The ash of the leaves has manurial value, and contains a good percentage of potash and phosphoric acid. The commercial ash obtained by burning the spent leaves of *E. polybractea*, at Wyalong, N.S.W., gave us the following results after fully carbonating; calculated on anhydrous material.

*Soluble in water:—*

|                    |     |            |   |       |           |
|--------------------|-----|------------|---|-------|-----------|
| Potassium sulphate | ... | $K_2SO_4$  | = | 8.63  | per cent. |
| „ chloride         | ... | $KCl$      | = | 20.95 | „         |
| Sodium carbonate   | ... | $Na_2CO_3$ | = | 14.61 | „         |

*Insoluble in water:—*

|                                          |     |              |   |       |   |
|------------------------------------------|-----|--------------|---|-------|---|
| Calcium phosphate                        | ... | $Ca_3P_2O_8$ | = | 8.45  | „ |
| „ carbonate                              | ... | $CaCO_3$     | = | 17.60 | „ |
| Magnesium carbonate                      | ... | $MgCO_3$     | = | 13.27 | „ |
| Iron, aluminium, and manganese oxides... | ... | ...          | = | 7.52  | „ |
| Carbon                                   | ... | ...          | = | 5.39  | „ |
| Sand, &c.                                | ... | ...          | = | 3.89  | „ |

The potash, as  $K_2O$ , was thus 17.97 per cent., and the phosphoric acid, as  $P_2O_5$ , 3.87 per cent.

In the *Bulletin of the Imperial Institute*, Vol. xvii, No. 3, p. 284, will be found an analysis of the ash of the young leaves and twigs of *E. globulus*. The potash in this, as  $K_2O$ , was 10.5 per cent., and the phosphoric acid, as  $P_2O_5$ , 2.35 per cent., whilst over 50 per cent. of the ash consisted of calcium carbonate.

## CONCLUSION



THE foregoing work, which has, *inter alia*, occupied our attention for a period of thirty years, and which embraces the investigation of individual species spreading over such a very wide area, serves to demonstrate the great economic importance of this remarkable Australian Genus, in other directions than for timber. Although the Industrial Applications of Eucalyptus Oils are now somewhat extensive, yet it must not be considered for a moment that these known results exhaust their economic possibilities, as, without doubt, in the coming years, new openings will be found for their employment, and new constituents be discovered.







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